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Maruyama et al.

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(45) **Date of Patent: May 15, 2012**

(54) **IMAGE DISPLAY SYSTEM, AN IMAGE DISPLAY METHOD, A CODING METHOD, AND A PRINTED MATTER FOR STEREOSCOPIC VIEWING**

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H04N 13/00 (2006.01)

(52) **U.S. Cl.** **348/42**; 348/51; 348/53; 348/115

(58) **Field of Classification Search** 348/42–53, 348/65, 115

See application file for complete search history.

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* cited by examiner

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(57) **ABSTRACT**

An image display system, an image display method, a coding method, and a printed matter for stereoscopic viewing are disclosed. The image display system includes a real image presentation unit for showing a first view image of the stereoscopic image as a real image, and a virtual image presentation unit for showing a second view image of the stereoscopic image as a virtual image, the second view image being based on the first view image. When the first view image is viewed by one eye of a viewing person, and the second view image is viewed by the other eye of the viewing person, the first view image and second view image together form the stereoscopic image.

15 Claims, 20 Drawing Sheets

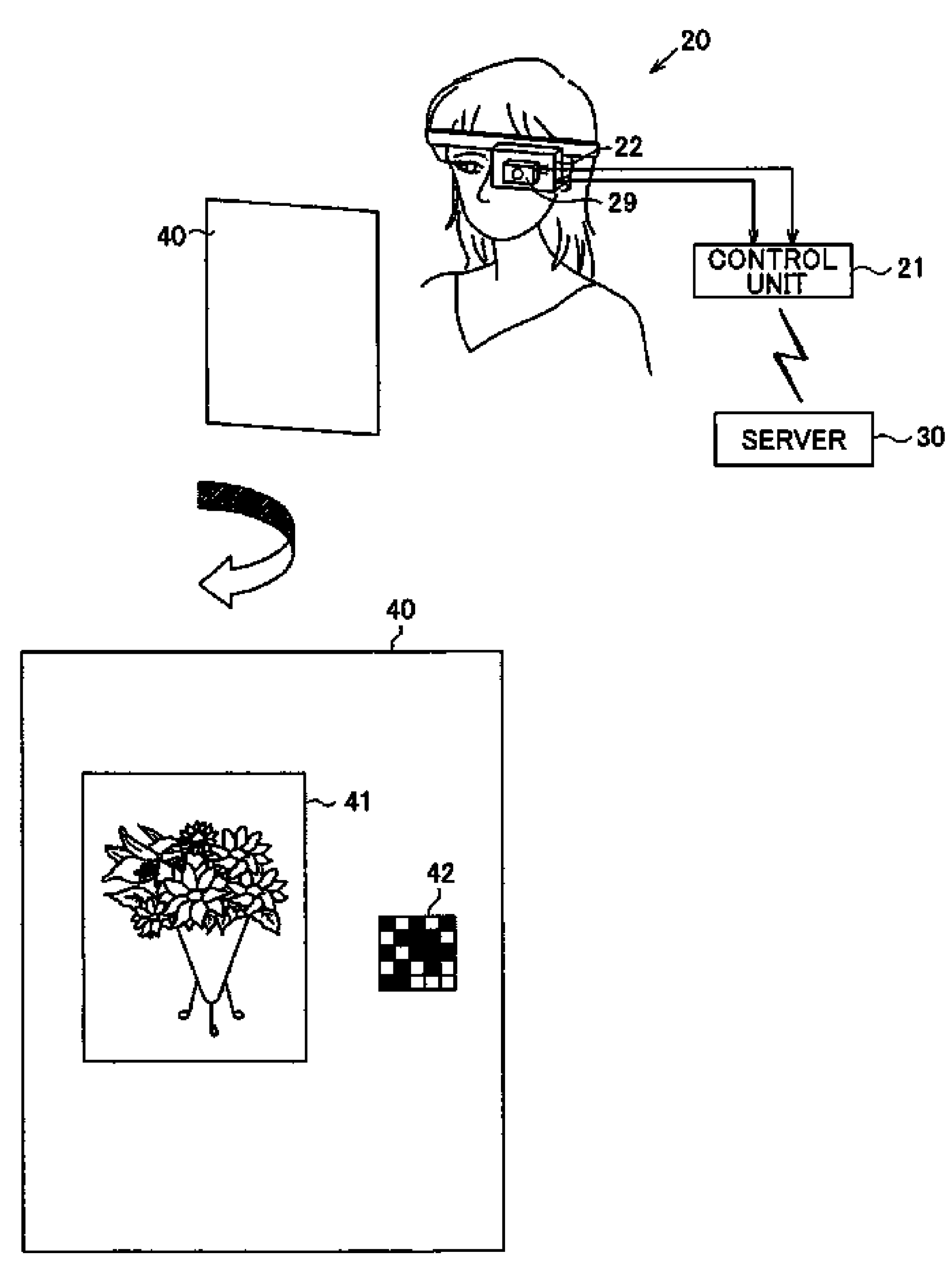

FIG.1

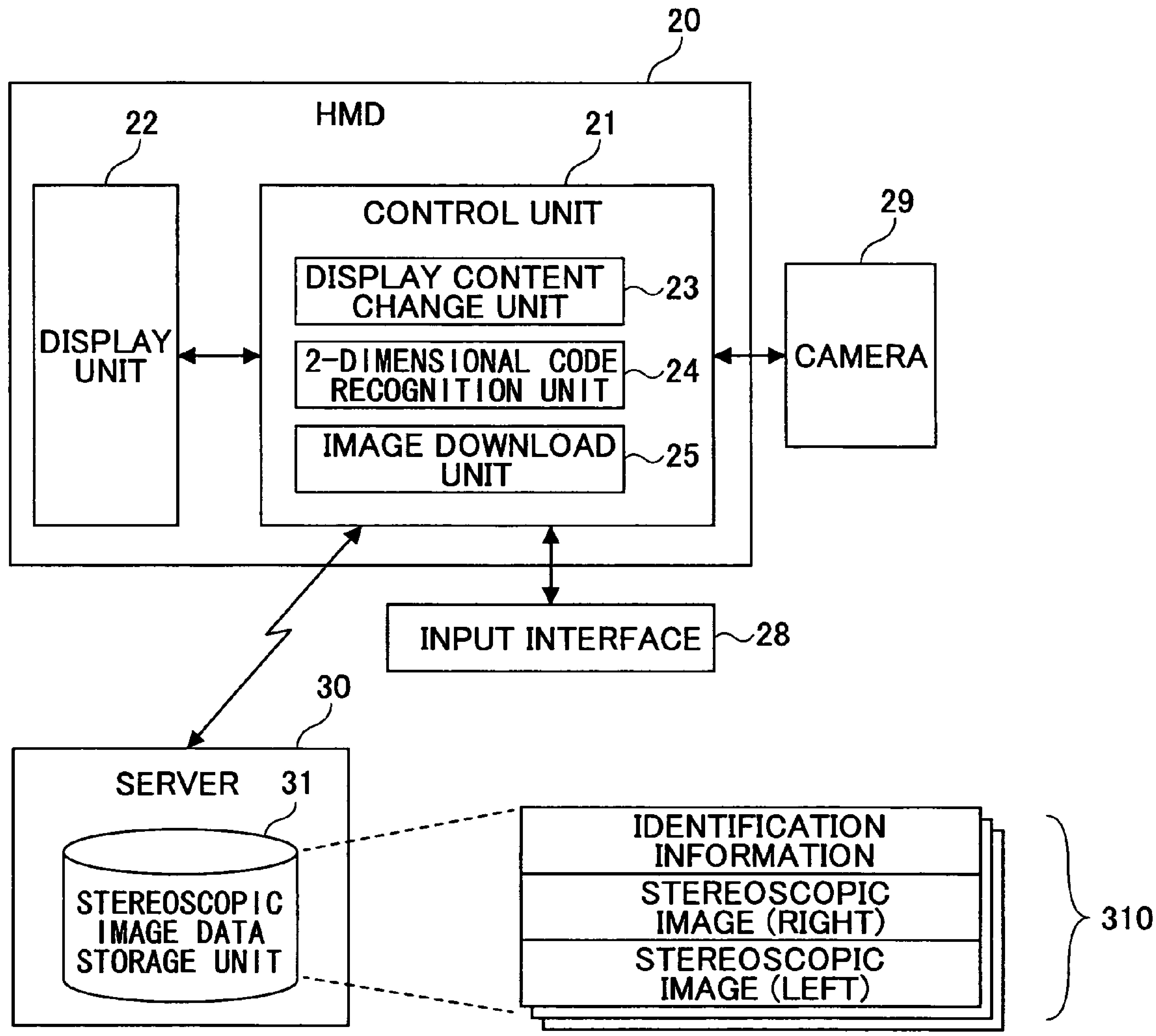
20
HMD
22
21
CONTROL UNIT
DISPLAY UNIT
DISPLAY CONTENT CHANGE UNIT
23
2-DIMENSIONAL CODE RECOGNITION UNIT
24
IMAGE DOWNLOAD UNIT
25
29
CAMERA
INPUT INTERFACE
28
30
SERVER
31
STEREOSCOPIC IMAGE DATA STORAGE UNIT
IDENTIFICATION INFORMATION
STEREOSCOPIC IMAGE (RIGHT)
STEREOSCOPIC IMAGE (LEFT)
310

FIG.2

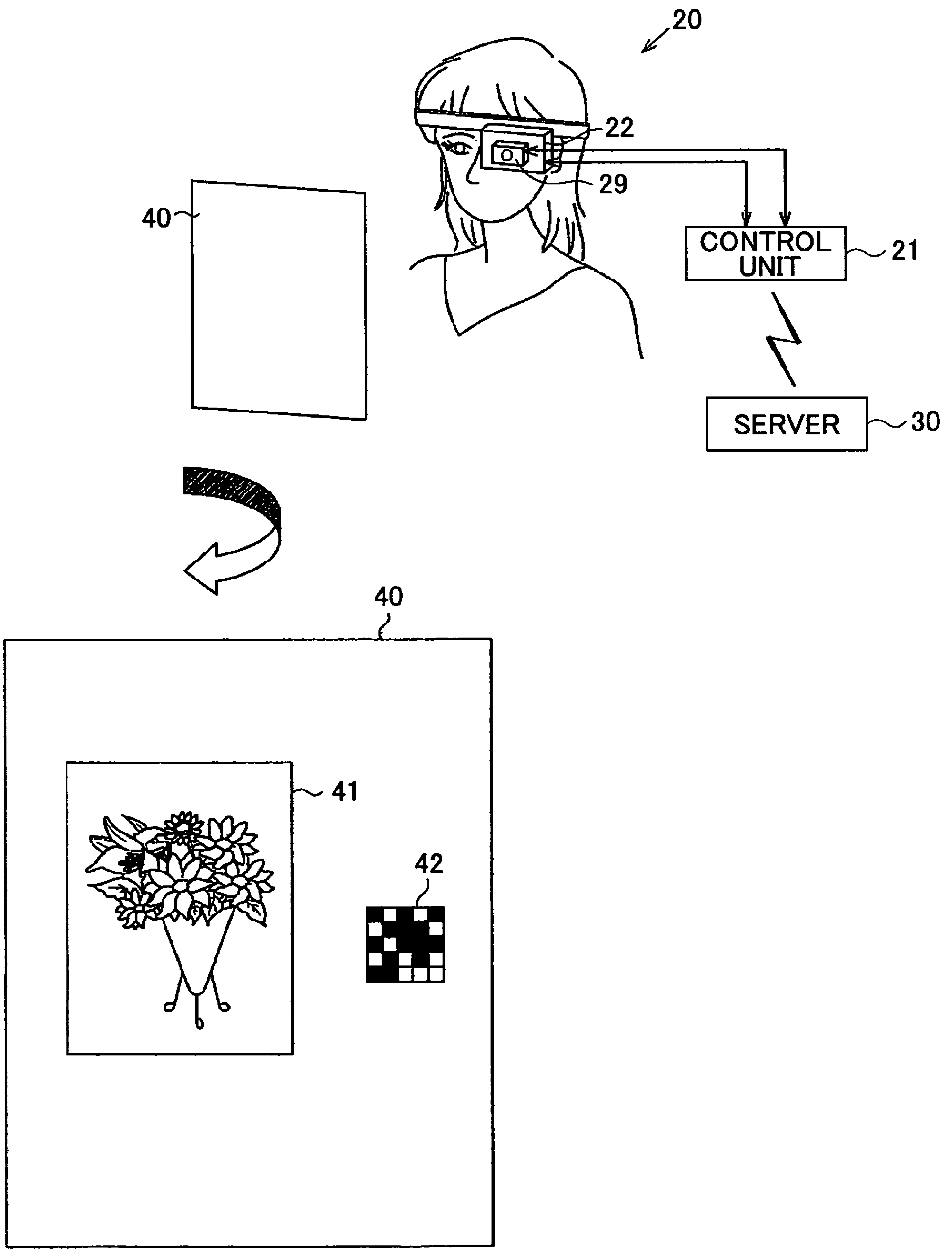

FIG.3

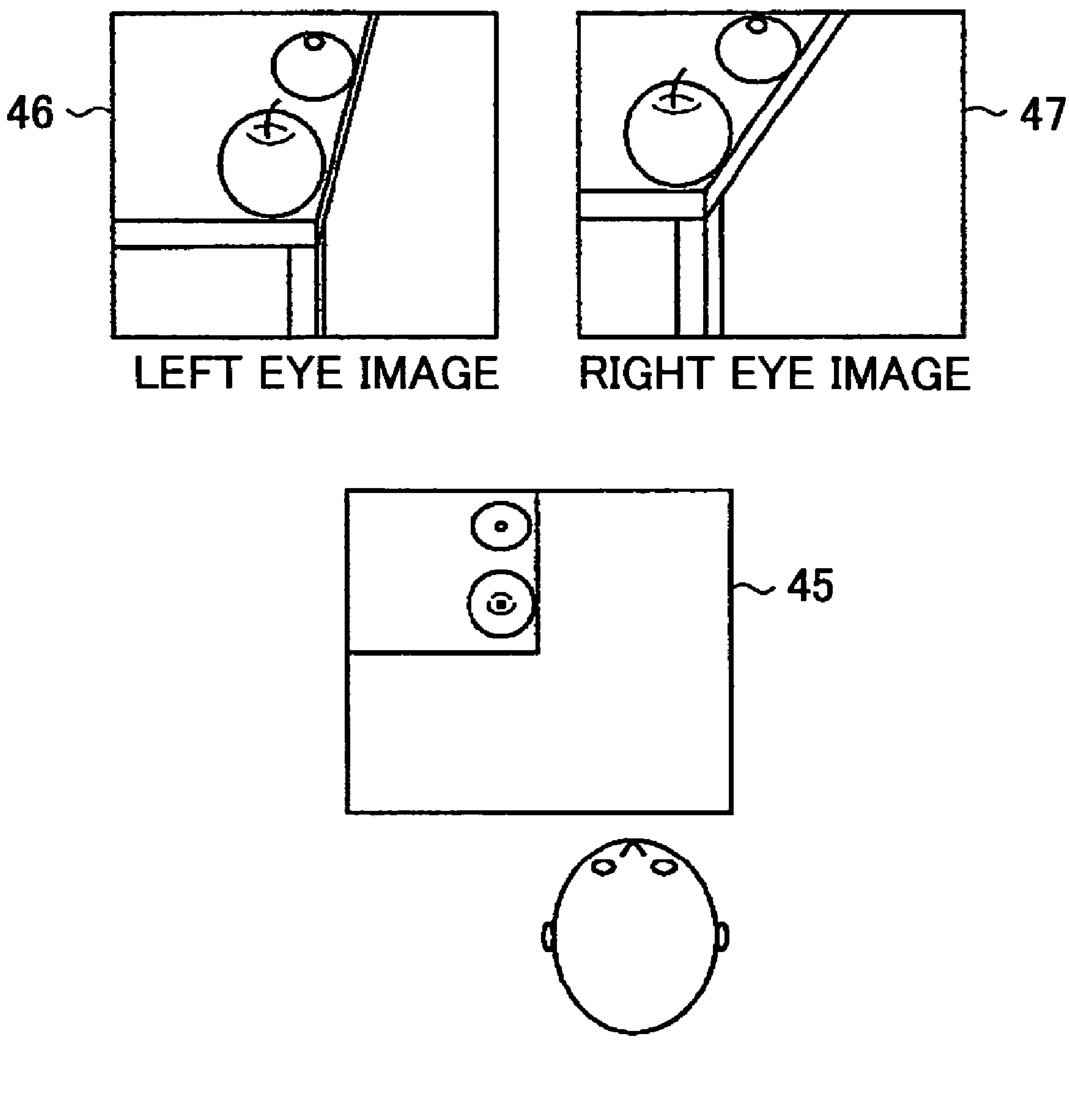

FIG.4

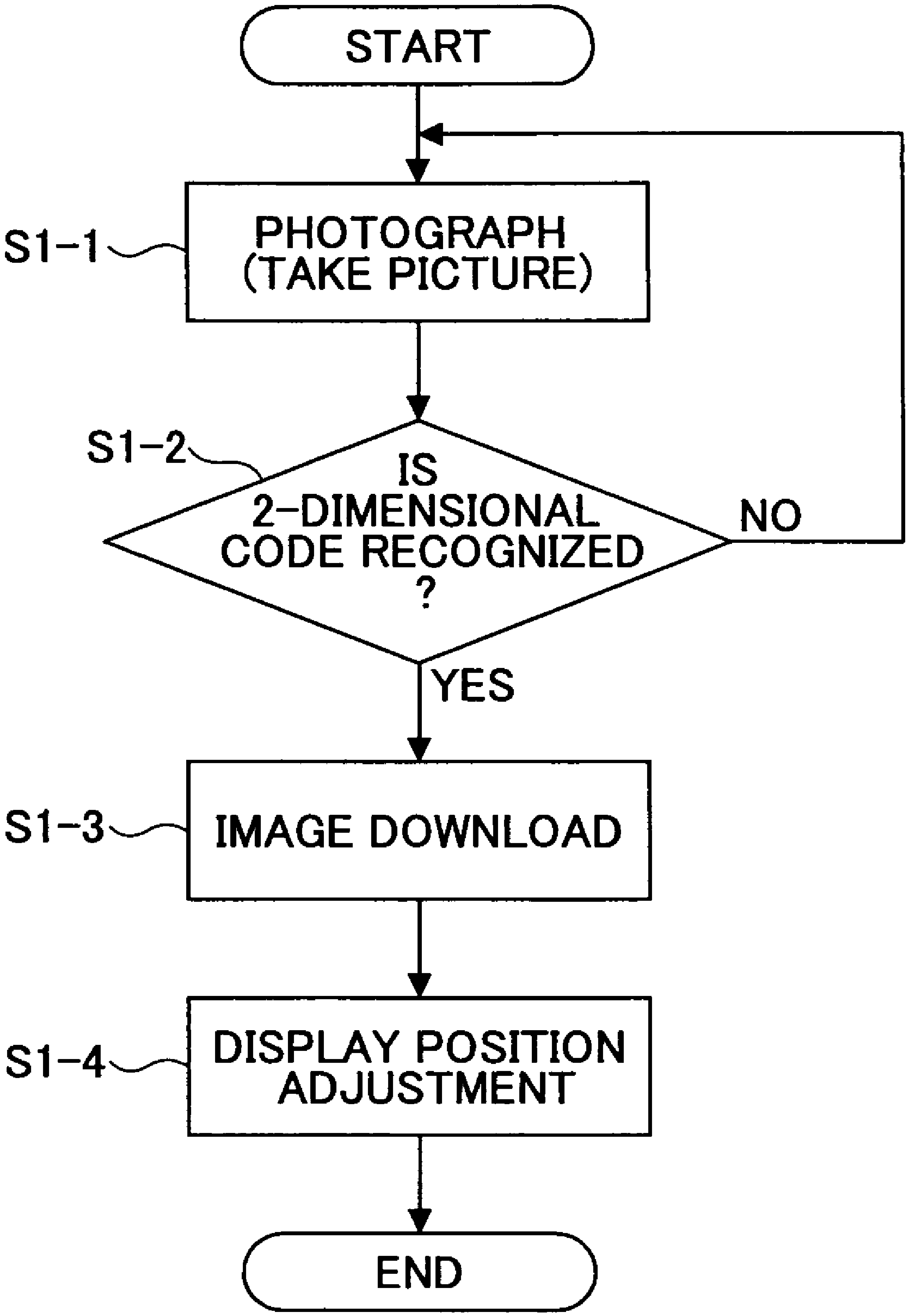
START
S1-1
PHOTOGRAPH (TAKE PICTURE)
S1-2
IS 2-DIMENSIONAL CODE RECOGNIZED ?
NO
YES
S1-3
IMAGE DOWNLOAD
S1-4
DISPLAY POSITION ADJUSTMENT
END

FIG.5

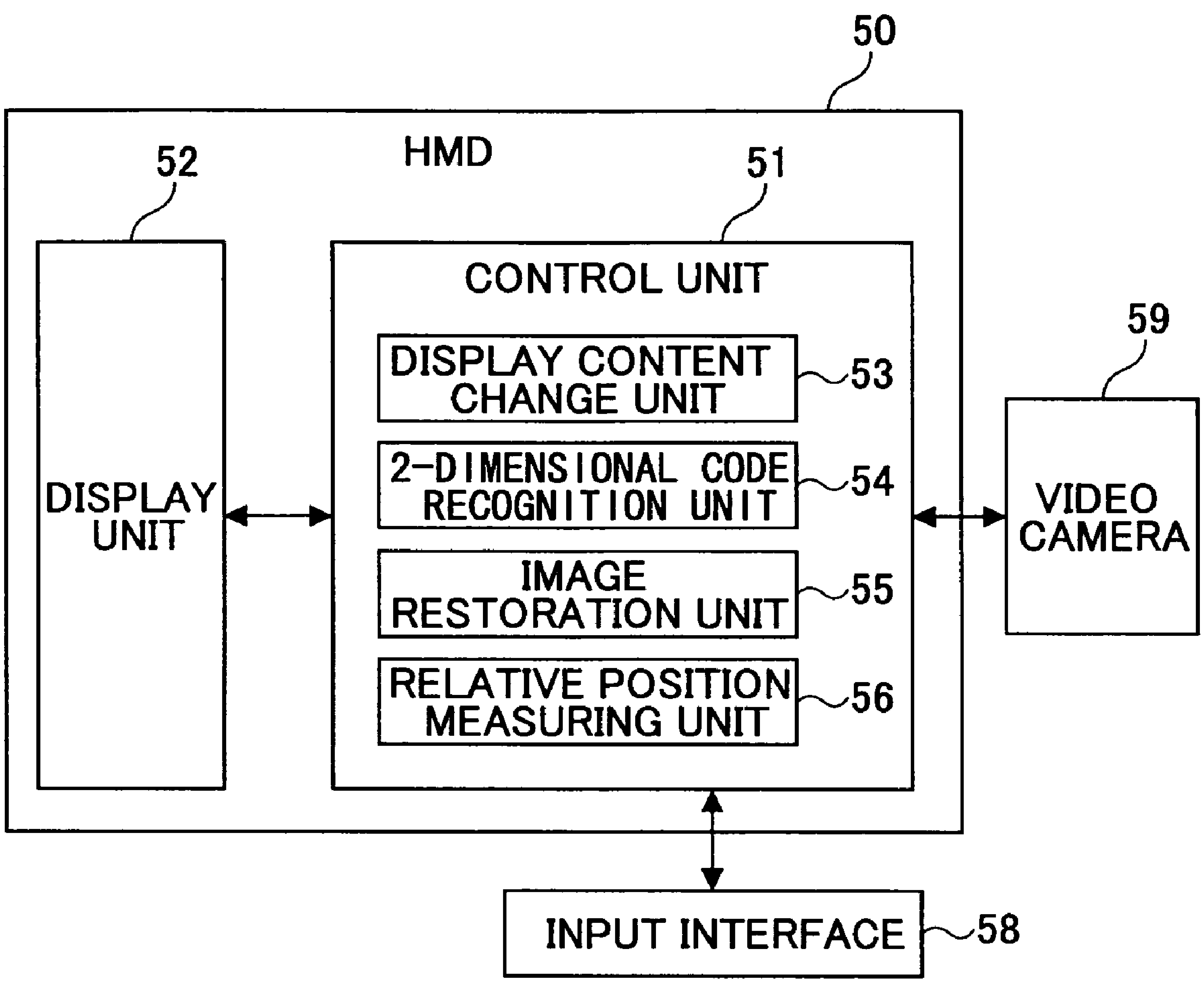
50
HMD
52
51
CONTROL UNIT
DISPLAY CONTENT CHANGE UNIT
53
2-DIMENSIONAL CODE RECOGNITION UNIT
54
IMAGE RESTORATION UNIT
55
RELATIVE POSITION MEASURING UNIT
56
DISPLAY UNIT
59
VIDEO CAMERA
INPUT INTERFACE
58

FIG.6

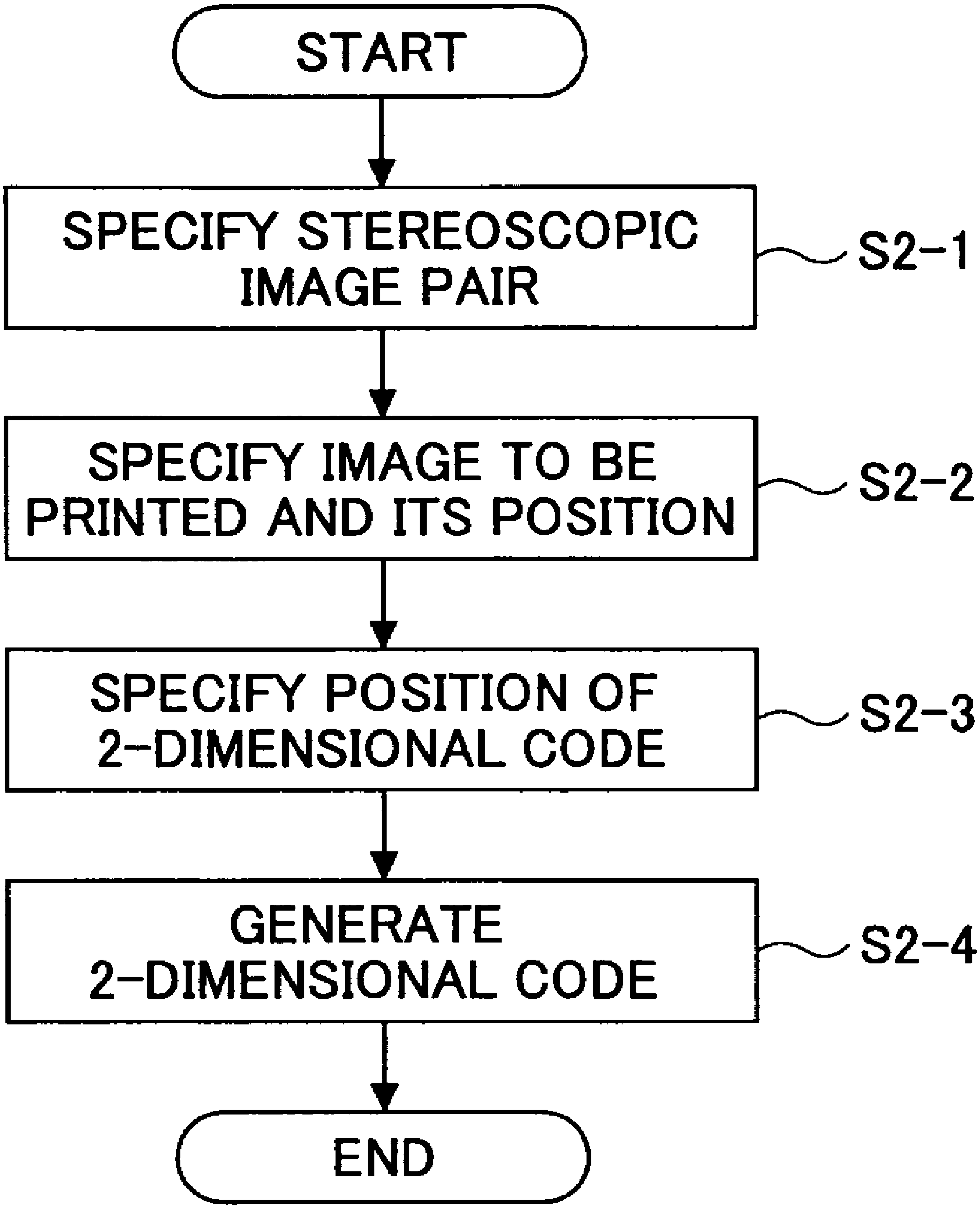
START
SPECIFY STEREOSCOPIC IMAGE PAIR
S2-1
SPECIFY IMAGE TO BE PRINTED AND ITS POSITION
S2-2
SPECIFY POSITION OF 2-DIMENSIONAL CODE
S2-3
GENERATE 2-DIMENSIONAL CODE
S2-4
END

FIG.7

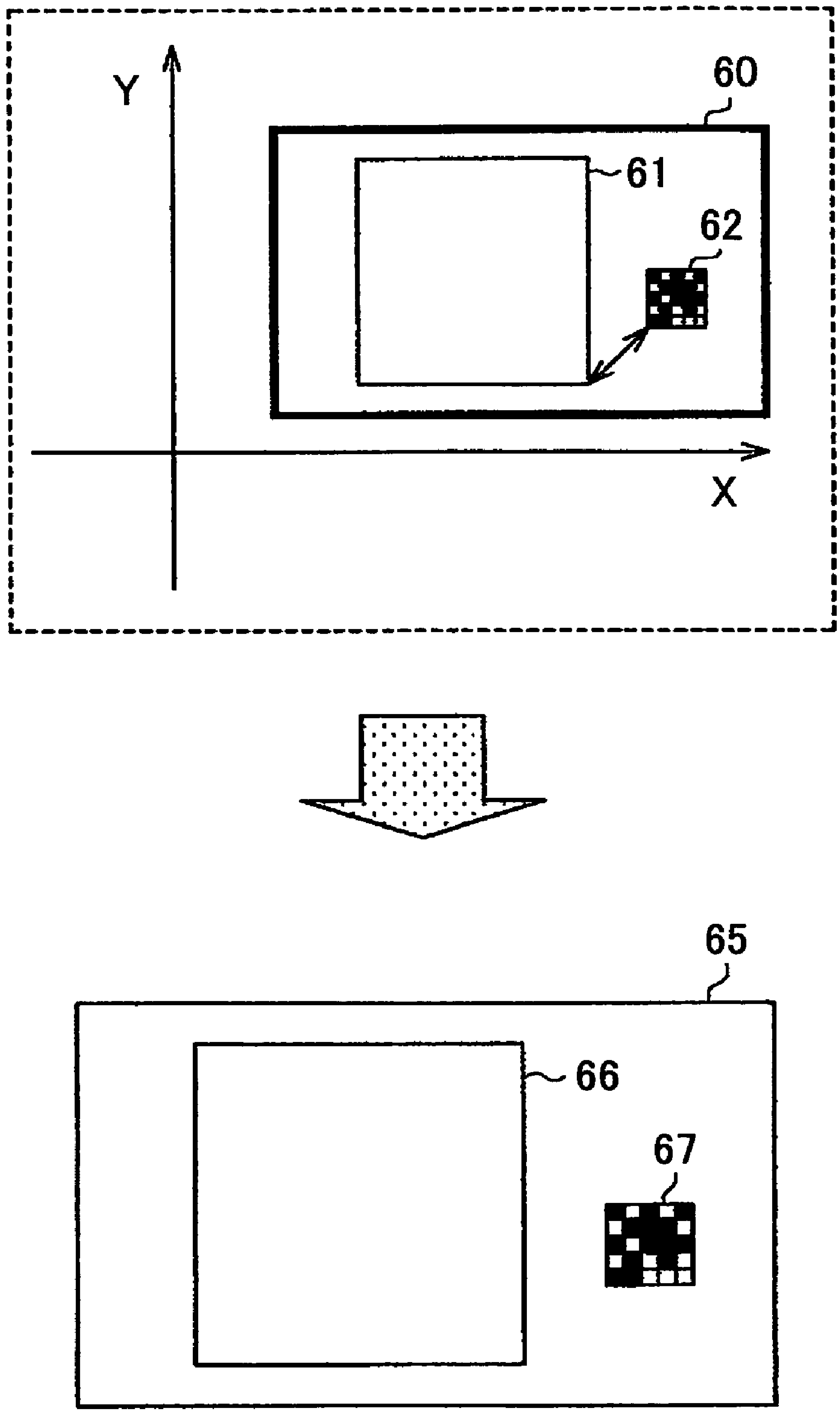

FIG.8

70

13	14	10	9
14	13	8	7
13	14	7	5
12	14	6	5

STEREOSCOPIC IMAGE FOR LEFT EYE

71

13	13	12	9
13	13	12	6
14	13	12	5
12	12	10	4

STEREOSCOPIC IMAGE FOR RIGHT EYE

72

0	−1	2	0
−1	0	4	−1
1	−1	5	0
0	−2	4	−1

DIFFERENCE IMAGE

FIG.9

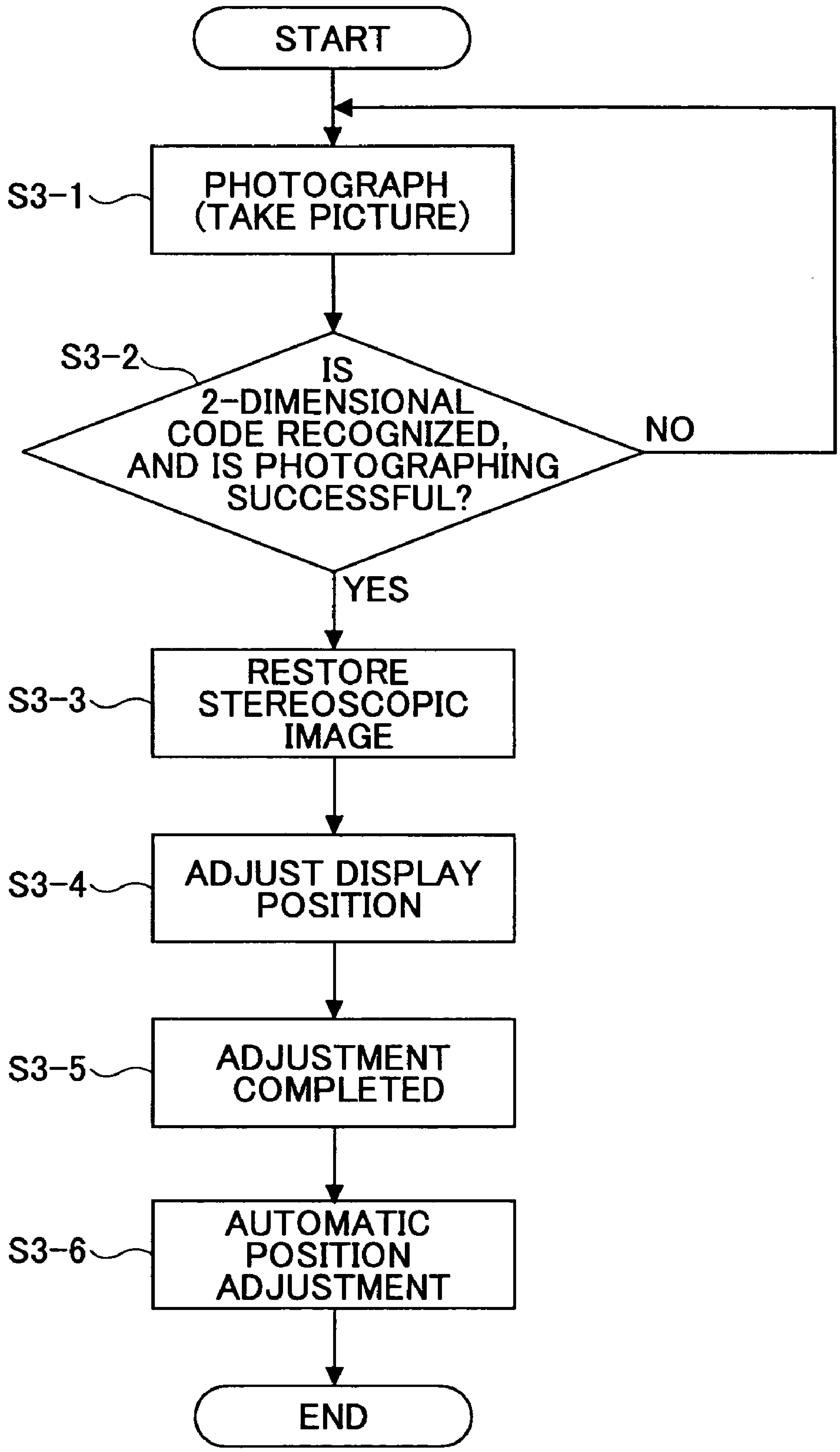
START
S3-1
PHOTOGRAPH (TAKE PICTURE)
S3-2
IS 2-DIMENSIONAL CODE RECOGNIZED, AND IS PHOTOGRAPHING SUCCESSFUL?
NO
YES
S3-3
RESTORE STEREOSCOPIC IMAGE
S3-4
ADJUST DISPLAY POSITION
S3-5
ADJUSTMENT COMPLETED
S3-6
AUTOMATIC POSITION ADJUSTMENT
END

FIG.10

73

13	14	13
12	15	13
0	1	14

PART OF FIRST FRAME

74

12	11	15
14	15	12
1	1	14

PART OF SECOND FRAME

75

25	25	28
26	30	25
1	2	28

PART OF SUPERPOSED IMAGE

FIG.11

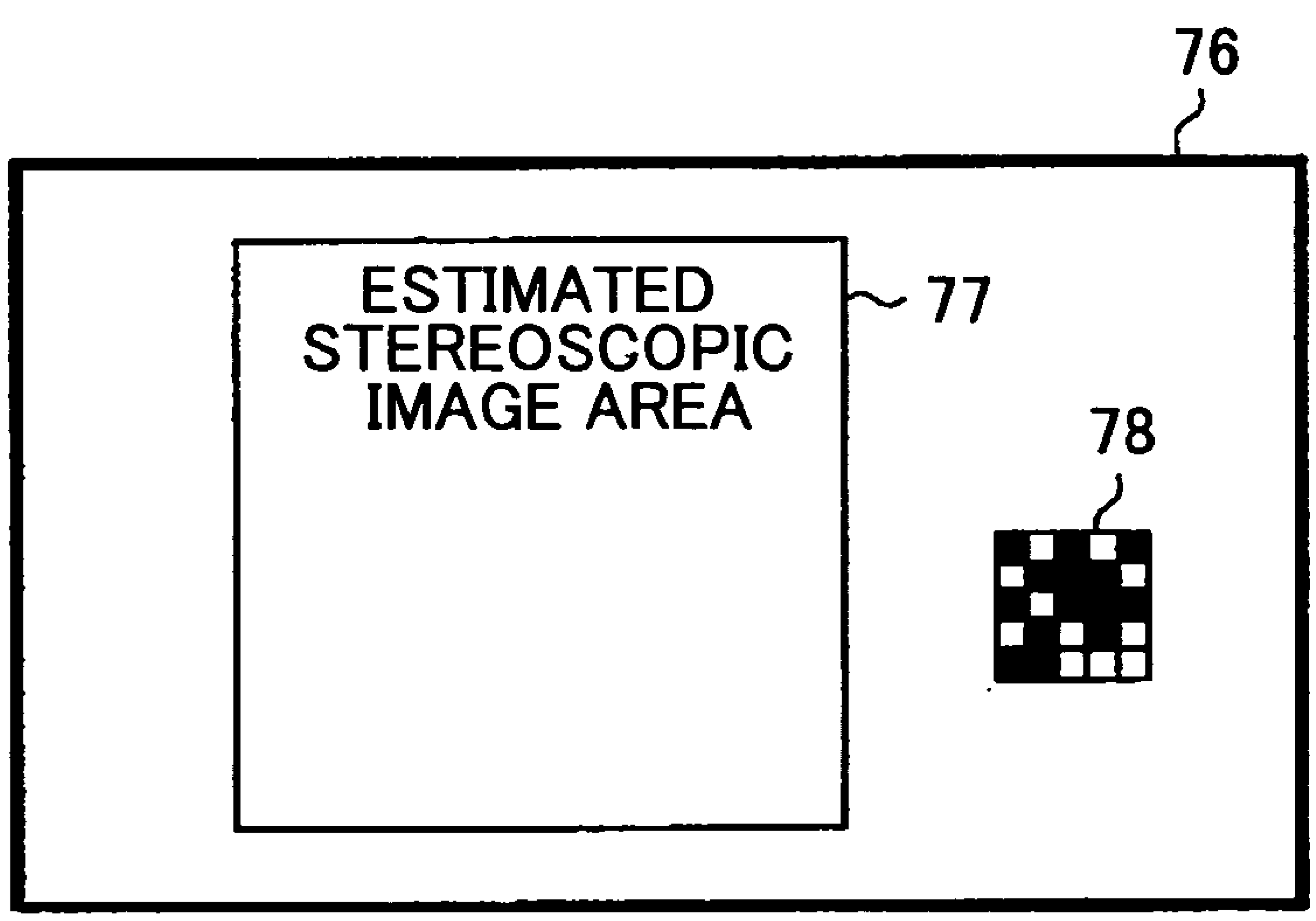

FIG.12

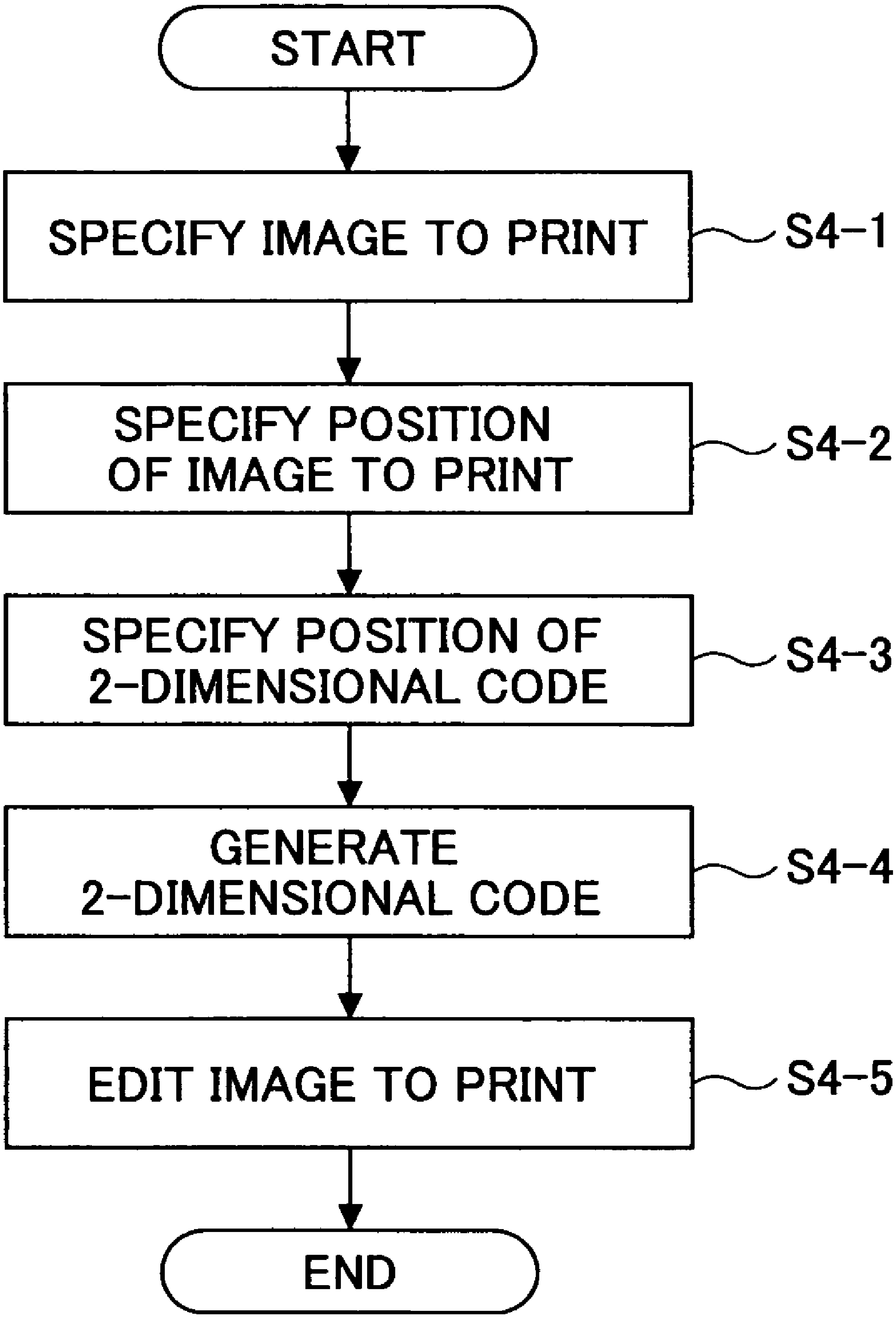
START
SPECIFY IMAGE TO PRINT
S4-1
SPECIFY POSITION OF IMAGE TO PRINT
S4-2
SPECIFY POSITION OF 2-DIMENSIONAL CODE
S4-3
GENERATE 2-DIMENSIONAL CODE
S4-4
EDIT IMAGE TO PRINT
S4-5
END

FIG.13

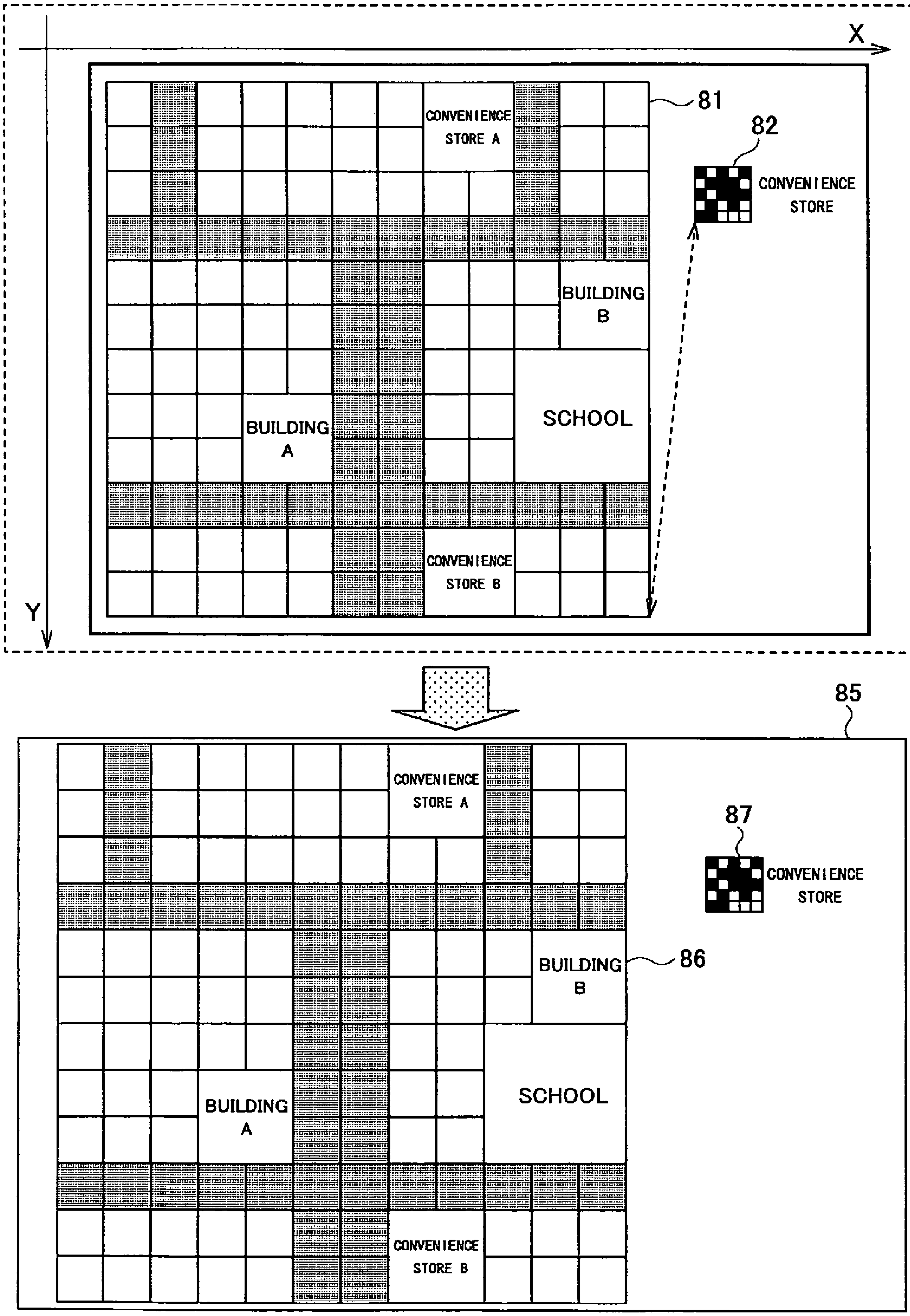
X
Y
81
82
CONVENIENCE STORE A
CONVENIENCE STORE
BUILDING B
SCHOOL
BUILDING A
CONVENIENCE STORE B
85
87
86

FIG.14

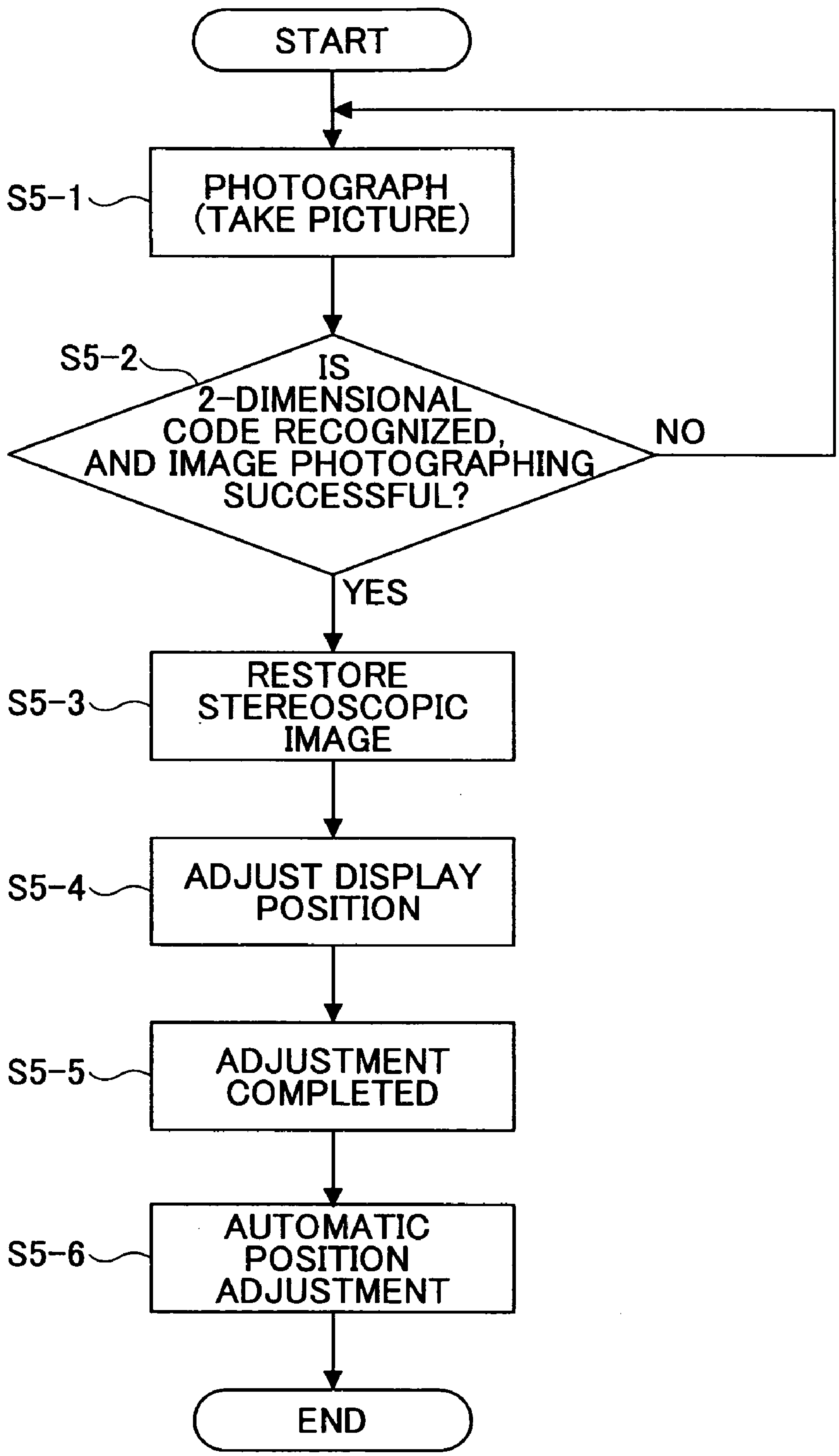
START
S5-1
PHOTOGRAPH
(TAKE PICTURE)
S5-2
IS
2-DIMENSIONAL
CODE RECOGNIZED,
AND IMAGE PHOTOGRAPHING
SUCCESSFUL?
NO
YES
S5-3
RESTORE
STEREOSCOPIC
IMAGE
S5-4
ADJUST DISPLAY
POSITION
S5-5
ADJUSTMENT
COMPLETED
S5-6
AUTOMATIC
POSITION
ADJUSTMENT
END

FIG.15

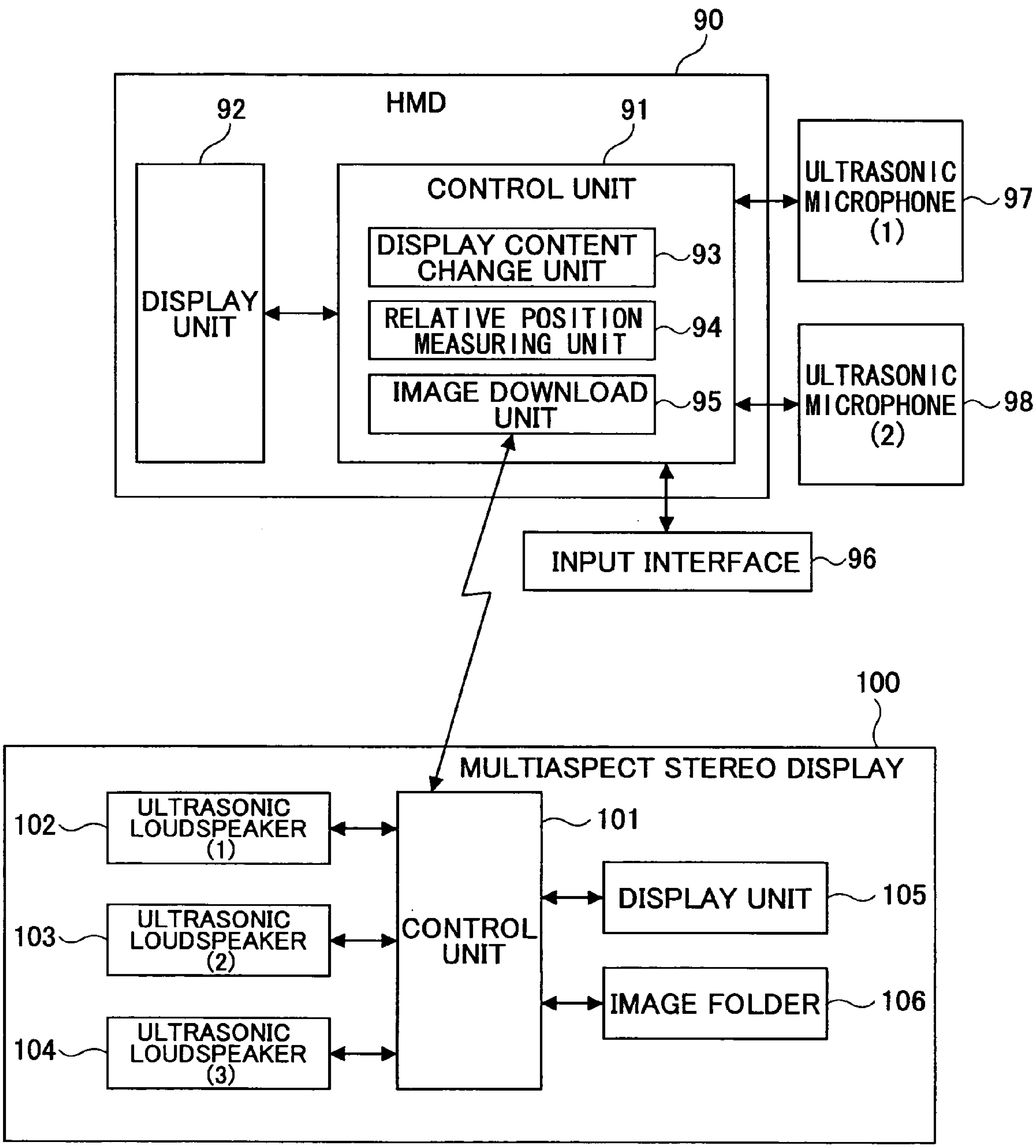
90
HMD
92
91
DISPLAY UNIT
CONTROL UNIT
DISPLAY CONTENT CHANGE UNIT
93
RELATIVE POSITION MEASURING UNIT
94
IMAGE DOWNLOAD UNIT
95
ULTRASONIC MICROPHONE (1)
97
ULTRASONIC MICROPHONE (2)
98
INPUT INTERFACE
96
100
MULTIASPECT STEREO DISPLAY
102
ULTRASONIC LOUDSPEAKER (1)
103
ULTRASONIC LOUDSPEAKER (2)
104
ULTRASONIC LOUDSPEAKER (3)
CONTROL UNIT
101
DISPLAY UNIT
105
IMAGE FOLDER
106

FIG.16

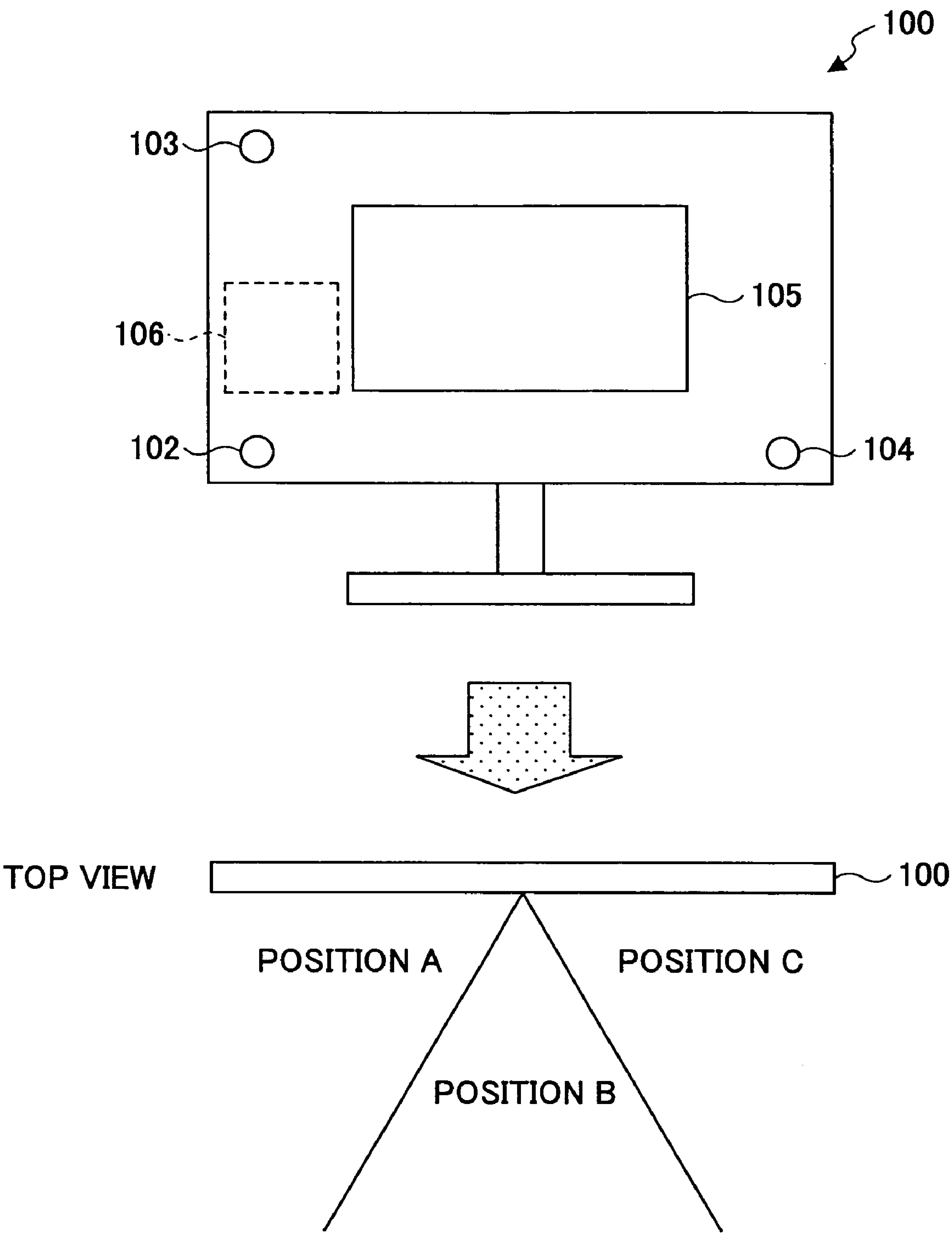
100
103
105
106
102
104
TOP VIEW
100
POSITION A
POSITION C
POSITION B

FIG.17

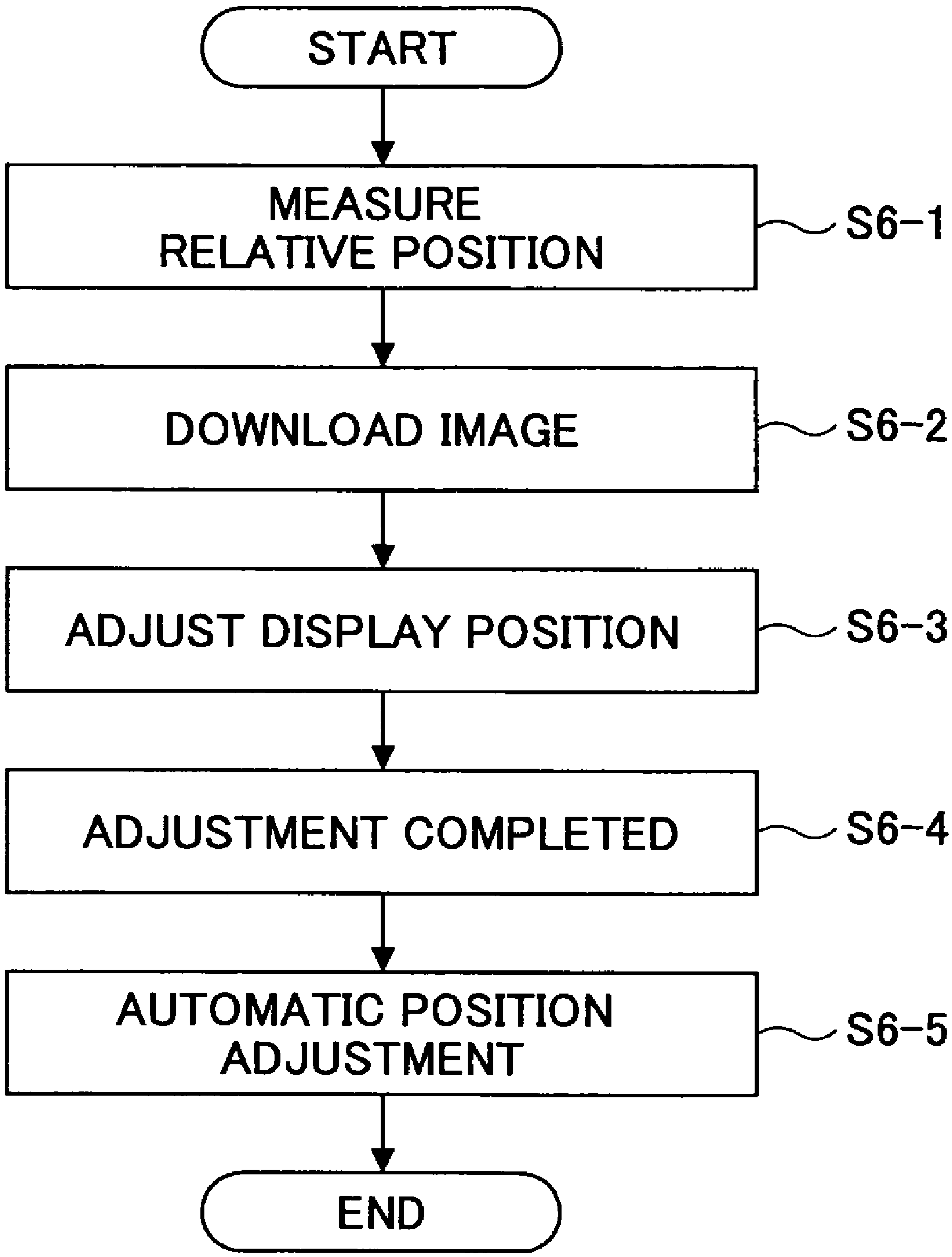
START
MEASURE RELATIVE POSITION
S6-1
DOWNLOAD IMAGE
S6-2
ADJUST DISPLAY POSITION
S6-3
ADJUSTMENT COMPLETED
S6-4
AUTOMATIC POSITION ADJUSTMENT
S6-5
END

FIG.18

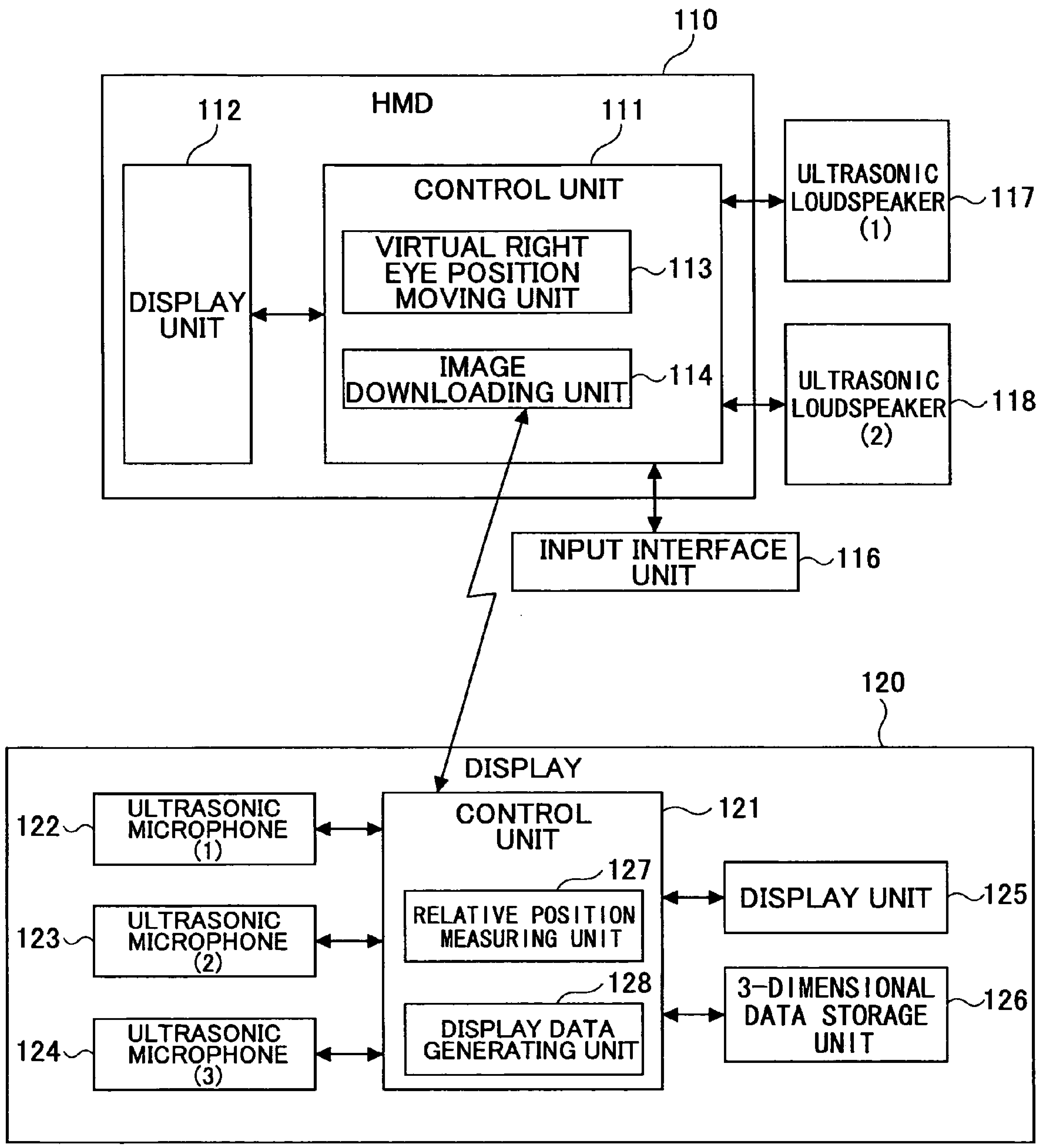
110
HMD
112
111
CONTROL UNIT
DISPLAY UNIT
VIRTUAL RIGHT EYE POSITION MOVING UNIT
113
IMAGE DOWNLOADING UNIT
114
ULTRASONIC LOUDSPEAKER (1)
117
ULTRASONIC LOUDSPEAKER (2)
118
INPUT INTERFACE UNIT
116
120
DISPLAY
122
ULTRASONIC MICROPHONE (1)
123
ULTRASONIC MICROPHONE (2)
124
ULTRASONIC MICROPHONE (3)
CONTROL UNIT
121
127
RELATIVE POSITION MEASURING UNIT
128
DISPLAY DATA GENERATING UNIT
DISPLAY UNIT
125
3-DIMENSIONAL DATA STORAGE UNIT
126

FIG.19

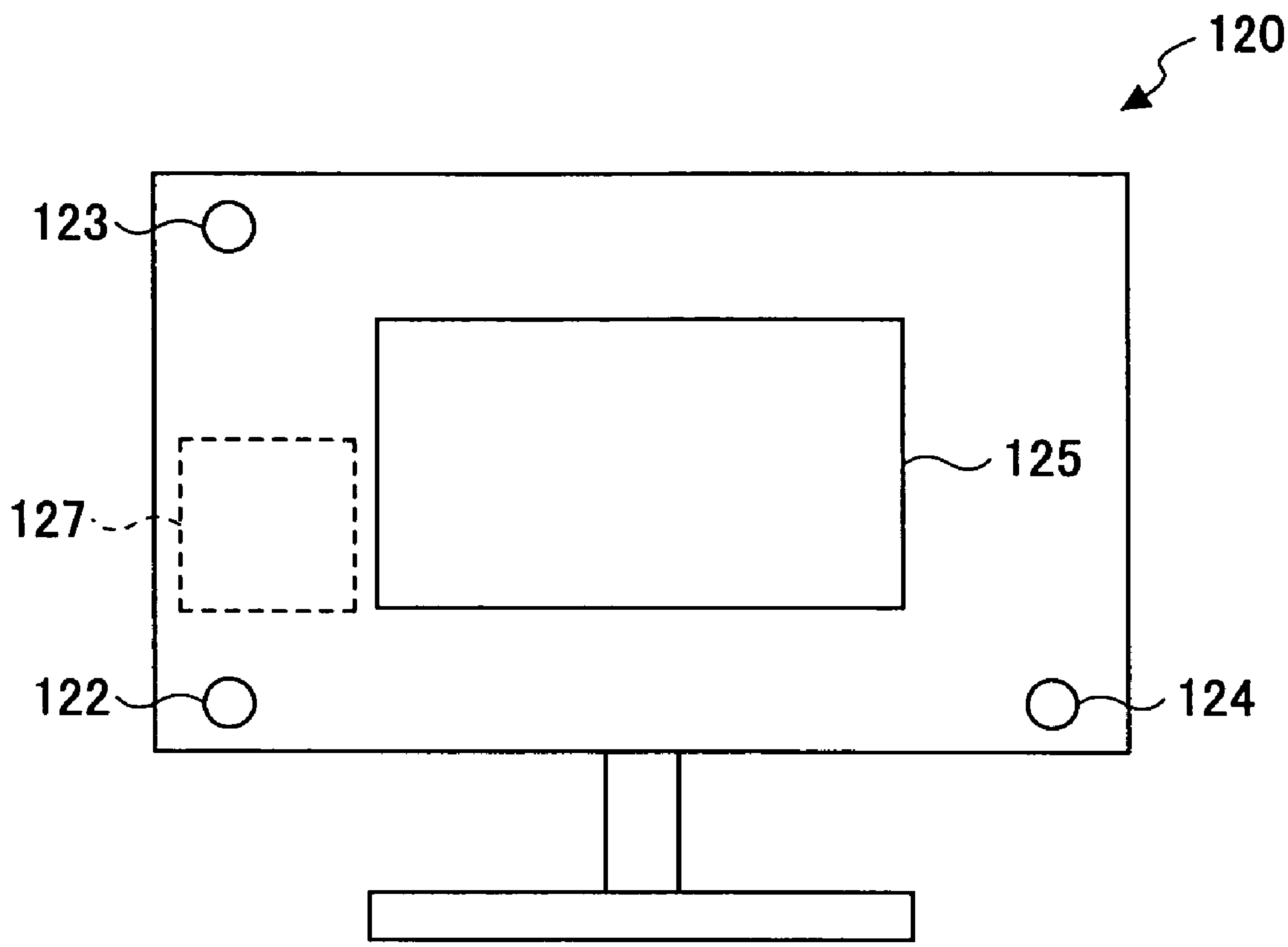

FIG.20

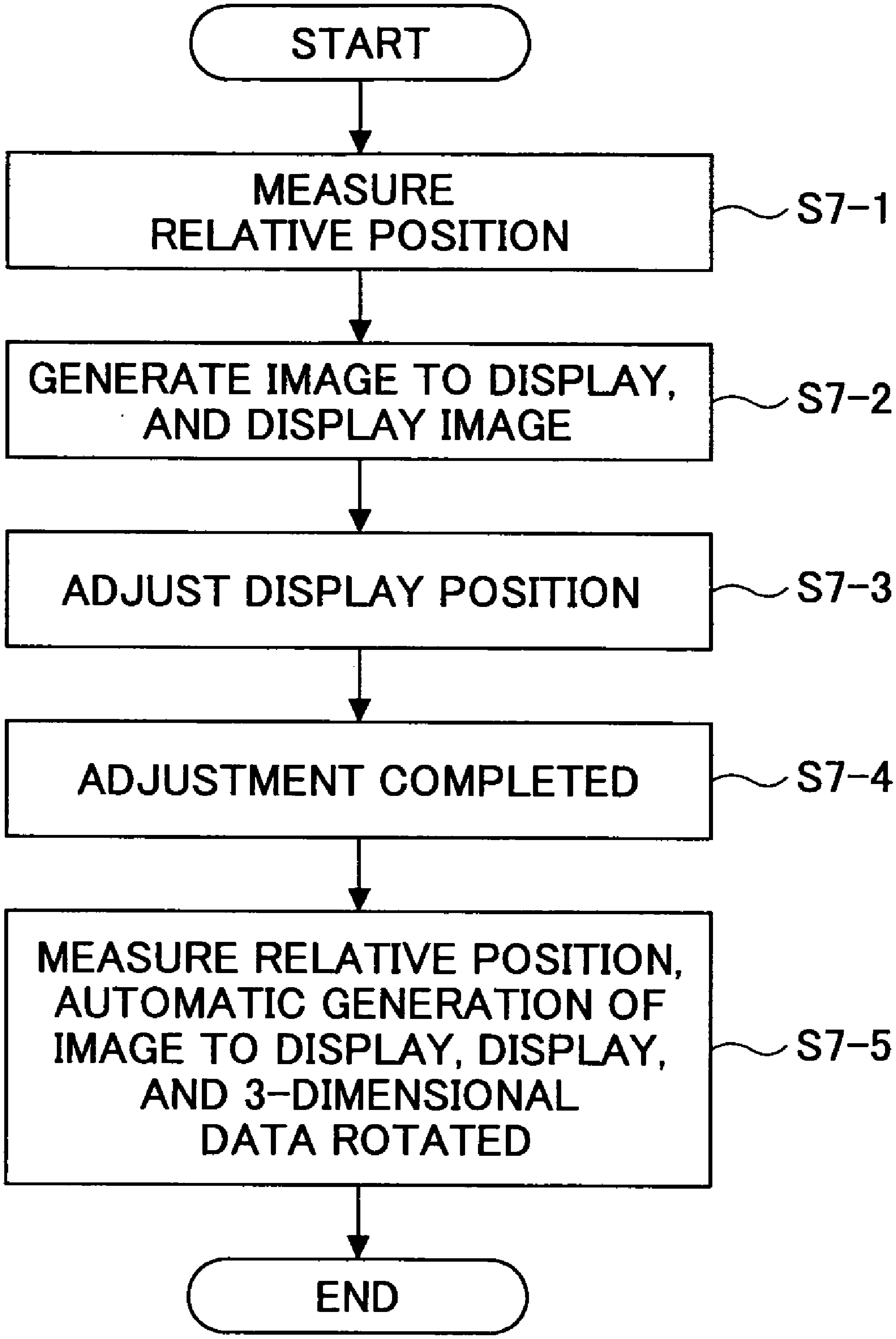
START
MEASURE RELATIVE POSITION
S7-1
GENERATE IMAGE TO DISPLAY, AND DISPLAY IMAGE
S7-2
ADJUST DISPLAY POSITION
S7-3
ADJUSTMENT COMPLETED
S7-4
MEASURE RELATIVE POSITION, AUTOMATIC GENERATION OF IMAGE TO DISPLAY, DISPLAY, AND 3-DIMENSIONAL DATA ROTATED
S7-5
END

FIG.21

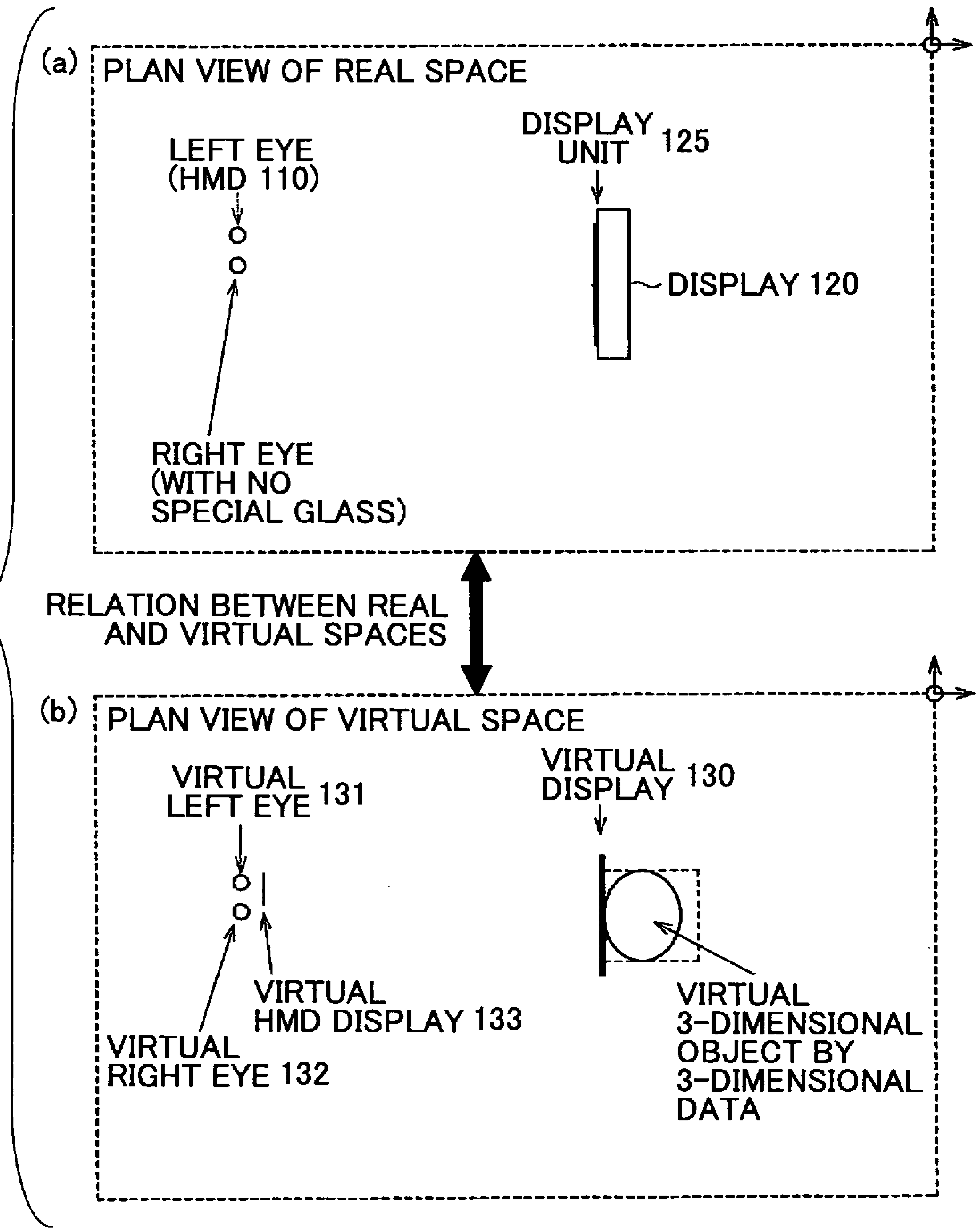
(a)
PLAN VIEW OF REAL SPACE
LEFT EYE (HMD 110)
DISPLAY UNIT 125
DISPLAY 120
RIGHT EYE (WITH NO SPECIAL GLASS)
RELATION BETWEEN REAL AND VIRTUAL SPACES
(b)
PLAN VIEW OF VIRTUAL SPACE
VIRTUAL LEFT EYE 131
VIRTUAL DISPLAY 130
VIRTUAL HMD DISPLAY 133
VIRTUAL RIGHT EYE 132
VIRTUAL 3-DIMENSIONAL OBJECT BY 3-DIMENSIONAL DATA

IMAGE DISPLAY SYSTEM, AN IMAGE DISPLAY METHOD, A CODING METHOD, AND A PRINTED MATTER FOR STEREOSCOPIC VIEWING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image display system, an image display method, a coding method, and a printed matter for stereoscopically viewing a 2-dimensional image.

2. Description of the Related Art

There are various image display systems for displaying or stereoscopically viewing a 3-dimensional object. Such image display systems can be classified into two groups, one being such as a parallax barrier system that does not require special glasses, and the other using special glasses such as liquid crystal shutter glasses and polarization glasses for both eyes (for example, Patent Reference 1). Patent Reference 1 discloses a system that includes

an image display unit for displaying a parallax image,

a deflection control unit for controlling deflection of display directivity of the parallax image in sync with the parallax image such that a horizontal single eye parallax image is displayed, and

a headset that is worn by a viewing person at the head or the face for displaying a vertical single eye parallax image in sync with the image display unit.

[Patent Reference 1] JPA 2000-347132 (pp. 4-7)

DESCRIPTION OF THE INVENTION

Problem(s) to be Solved by the Invention

According to the conventional technology as described above, if the viewing person has to wear glasses (i.e., for both eyes), he/she cannot see surrounding circumstances, and he/she cannot efficiently walk or act otherwise. Further, it is difficult to share the same stereoscopic image by two or more persons. For example, even if the same stereoscopic image may be viewed by the persons, one cannot tell which portion of the image another is viewing. Certainly, it is possible to use an AR technology such that the other person is superposed in the image being displayed. Nevertheless, it is difficult to provide a feeling of reality. Further, if wearing the glasses is not required, the viewing person has to stay at a predetermined position according to the conventional technology. If the viewing person moves from the predetermined position, physiological sense of discomfort and unpleasantness may arise.

SUMMARY OF THE INVENTION

The present invention provides an image display system, an image display method, a coding method, and a printed matter for stereoscopic viewing that substantially obviate one or more of the problems caused by the limitations and disadvantages of the related art.

More specifically, according to the present invention, stereoscopic viewing is provided to a viewing person with one of his/her eyes being kept available for viewing the external world, and he/she can move without losing comfortable stereoscopic viewing. That is, flexible stereoscopic viewing is provided.

Features of embodiments of the present invention are set forth in the description that follows, and in part will become apparent from the description and the accompanying drawings, or may be learned by practice of the invention according to the teachings provided in the description. Problem solutions provided by an embodiment of the present invention will be realized and attained by an image display system, an image display method, a coding method, and a printed matter for stereoscopic viewing particularly pointed out in the specification in such full, clear, concise, and exact terms as to enable a person having ordinary skill in the art to practice the invention.

To achieve these solutions and in accordance with an aspect of the invention, as embodied and broadly described herein, an embodiment of the invention provides an image display system, an image display method, a coding method, and a printed matter for stereoscopic viewing as follows.

Means for Solving the Problem

A preferred embodiment of the present invention provides an image display system for stereoscopic viewing a stereoscopic image, including:

a real image presentation unit for showing a first view image of the stereoscopic image as a real image; and

a virtual image presentation unit for showing a second view image of the stereoscopic image as a virtual image, the second view image being based on the first view image;

wherein the first view image is viewable by one eye of a viewing person, and the second view image is viewable by the other eye of the viewing person, which first view image and second view image together form the stereoscopic image.

According to an aspect of the present invention, the real image presentation unit is a printed matter.

According to another aspect of the present invention, the real image presentation unit is a display unit.

According to an aspect of the present invention, the virtual image presentation unit displays the second view image, serving as the as virtual image, based on an image photographed by an image pick-up unit

According to another aspect of the present invention, the virtual image presentation unit includes an image pick-up unit for taking an image of a code image that indicates an address, such as a URL, of the second view image, and

the virtual image presentation unit shows the second view image, serving as the virtual image, stored at the address that the code image photographed by the image pick-up unit indicates.

According to another aspect of the present invention, the virtual image presentation unit includes an image pick-up unit for taking an image of the first view image and a code image, the code image containing data representing differences between the first view image and the second view image, and

the virtual image presentation unit generates the second view image based on the first view image and the code image that are photographed by the image pick-up unit, and shows the second view image as the virtual image.

According to another aspect of the present invention, the virtual image presentation unit includes an image pick-up unit for taking an image of the first view image and a code image, the code image containing data representing a portion of the first view image that is to be shown with an elevation using parallax, and

the virtual image presentation unit generates the second view image based on the first view image and the code image that are photographed by the image pick-up unit, and shows the second view image as the virtual image.

According to another aspect of the present invention, the real image presentation unit presents two or more first view images corresponding to different positions as the real image, and

the virtual image presentation unit presents the second view image, serving as the virtual image, corresponding to the first view image shown by the real image presentation unit.

According to another aspect of the present invention, the real image presentation unit presents the first view image as the real image according to a position relation between the virtual image presentation unit and the real image presentation unit, and

the virtual image presentation unit presents the second view image as the virtual image corresponding to the first view image according to the position relation between the virtual image presentation unit and the real image presentation unit.

According to another aspect of the present invention, the virtual image presentation unit is a head wearing type single eye display unit.

According to another aspect of the present invention, the image display system includes a relative position determining unit for determining a relative position between the virtual image presentation unit and the real image presentation unit.

According to another aspect of the present invention, the relative position determining unit includes an image pick-up unit.

According to another aspect of the present invention, the image display system includes a display data transforming unit for carrying out projective transformation on display data of the second view image shown by the virtual image presentation unit.

According to another aspect of the present invention, the image display system includes a display data status selecting unit for carrying out projective transformation on display data of the second view image displayed by the virtual image presentation unit according to an operation of the viewing person, and for the viewing person to select a state of the display data.

According to another aspect of the present invention, the image display system includes a relative position determining unit for determining a relative position between the virtual image presentation unit and the real image presentation unit, and a display data automatic transformation unit for automatically carrying out the projective transformation on the display data of the second view image shown by the virtual image presentation unit based on information about the selection of the user by the display data status selecting unit and based on the relative position.

The embodiment of the present invention further provides an image display method for stereoscopic viewing a stereoscopic image, including:

using a real image presentation unit for showing a first view image of the stereoscopic image as a real image, and

using a virtual image presentation unit for showing a second view image of the stereoscopic image as a virtual image, the second view image being based on the first view image;

wherein the first view image, when viewed by one eye of a viewing person, and the second view image, when viewed by the other eye of the viewing person, together form the stereoscopic image.

According to an aspect of the present invention, the image display method includes

a step of generating a code image that contains coded information about a relative position and relative size between the code image and the stereoscopic image, the code image being appended to the stereoscopic image.

An aspect of the present invention provides a printed matter for stereoscopic viewing, on which printed matter a first view image in consideration of parallax with reference to a second view image is printed, comprising:

a code image being printed on the printed matter, the code image indicating an address of the second view image.

Another aspect of the present invention provides the printed matter for stereoscopic viewing wherein the code image contains data representing differences between the first view image and the second view image.

Another aspect of the present invention provides the printed matter for stereoscopic viewing wherein the code image contains data expressing a portion of the first view image, which portion is viewed with an elevation by parallax by moving the portion in the virtual image.

Another aspect of the present invention provides the printed matter for stereoscopic viewing, wherein the code image contains data expressing a portion of the first view image, which portion is viewed with an elevation by parallax by moving the portion in the virtual image.

Effect of the Invention

According to one or more embodiments of the present invention, flexible stereoscopic viewing is obtained, the viewing person being capable of seeing the external world by one of the two eyes, and individual physical differences being adjusted.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an image display system according to a first embodiment of the present invention;

FIG. **2** is a schematic diagram for describing an operation of a head mount display;

FIG. **3** is a schematic diagram of images viewed by each of the eyes;

FIG. **4** is a flowchart of a process according to the first embodiment;

FIG. **5** is a block diagram of the image display system according to a second embodiment of the present invention;

FIG. **6** is a flowchart of a process according to the second embodiment;

FIG. **7** is a schematic diagram showing a stereoscopic image printed on paper;

FIG. **8** gives pixel maps showing a difference image obtained from a stereoscopic image (for the right eye) and a stereoscopic image (for the left eye);

FIG. **9** is a flowchart of a process according to the second embodiment;

FIG. **10** gives data maps showing a superposed image obtained from a first frame and a second frame;

FIG. **11** is a schematic diagram showing a position of the superposed image;

FIG. **12** is a flowchart of a process according to the third embodiment of the present invention;

FIG. **13** is a schematic diagram explaining printing a map on the paper;

FIG. **14** is a flowchart of a process according to the third embodiment;

FIG. **15** is a block diagram of the image display system according to the fourth embodiment of the present invention;

FIG. **16** is a schematic diagram showing a position of the viewing person according to the fourth embodiment;

FIG. **17** is a flowchart of a process according to the fourth embodiment;

FIG. **18** is a block diagram of the image display system according to the fifth embodiment of the present invention;

FIG. **19** is a schematic diagram of a display that includes an ultrasonic microphone;

FIG. **20** is a flowchart of a process according to the fifth embodiment; and

FIG. **21** is a schematic diagram showing a correspondence between an actual space (a) and a virtual space (b).

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, embodiments of the present invention are described with reference to the accompanying drawings.

First Embodiment

In the following, the first of embodiments that realize one or aspects of the present invention is described with reference to FIG. **1** through FIG. **4**. An image display system, an image display method, and a printed matter for stereoscopic viewing according to the first embodiment are described, whereby a viewing person obtains flexible stereoscopic viewing with one of his/her eyes being available for seeing the external world. According to the first embodiment, a first view image and a second view image are prepared, considering parallax. Then, the first view image is printed on paper (printed matter for stereoscopic viewing) to be viewed with one eye, and the second image is displayed by a head mount display to be viewed by the other eye. More specifically, a 2-dimensional code representing identification information of the first view image data is printed on the paper (printed matter for stereoscopic viewing) in addition to the first view image that represents a real image. The first view image on the printed matter for stereoscopic viewing is seen by one eye of the viewing person. The second view image is provided by a server based on the identification information specified by the 2-dimensional code, is displayed by the head mount display, and is viewed by the other eye of the viewing person. In this way, the stereoscopic viewing is made possible. That is, the printed matter for stereoscopic viewing constitutes a real image presentation unit according to the present embodiment. Further, the head mount display constitutes a virtual image presentation unit. In this specification, an image that can be seen without using a virtual image presentation unit is called a real image, and an image displayed by the virtual image presentation unit is called a virtual image.

As shown in FIG. **1**, the head mount display is called HMD **20**, and includes a control unit **21** and a display unit **22** that is connected to the control unit **21**. The control unit **21** includes a display content change unit **23**, a 2-dimensional code recognition unit **24**, and an image downloading unit **25**. The control unit **21** includes CPU, RAM, and ROM (not illustrated), and performs a process that is described below. The display content change unit **23**, the 2-dimensional code recognition unit **24**, and the image downloading unit **25** of the control unit **21** carry out functions according to a program for the process.

The display content change unit **23** adjusts an image displayed on the display unit **22** by carrying out projective transformation (a rotational conversion, and a parallel conversion) of the image according to an operation of an input interface **28** by the viewing person. That is, the display content change unit **23** functions as a display data deformation unit and a display data status selection unit.

The 2-dimensional code recognition unit **24** determines whether there is identification information in an image that

has been photographed with an image pick-up unit such as a camera **29**. If the determination is affirmative, the 2-dimensional code recognition unit **24** directs the image downloading unit **25** to start processing.

Then, the image downloading unit **25** downloads a stereo (virtual) image identified by the identification information from a server **30**, and displays the stereo (virtual) image on the display unit **22**.

The display unit **22** is for displaying information processed by the control unit **21**.

Further, the control unit **21** is connected to the camera **29** that takes an image of the paper **40** (refer to FIG. **2**) through a lens. The camera **29** is arranged in a position such that an image pick-up plane thereof is in parallel with the display unit **22**, and the center of the optical axis thereof is in agreement with the center of the display unit **22**. The image taken by the camera **29** is provided to the control unit **21**.

Further, the control unit **21** is connected to the input interface **28**. The input interface **28** includes a pointing device, such as a mouse, for adjusting an image displayed on the display unit **22**.

Here, the HMD **20** is connected to the server **30** by a cable and/or radio. The server **30** includes CPU, RAM, ROM (not illustrated), a stereoscopic image data storage unit **31**, and a communicating unit (not illustrated).

The stereoscopic image data storage unit **31** stores stereoscopic image data **310**. When an image for stereoscopic viewing is specified, the stereoscopic image data **310** are generated and recorded on the paper **40** (FIG. **2**). The stereoscopic image data **310** include data about identification information, a stereoscopic image (right), and a stereoscopic image (left).

Data for specifying a stereoscopic image are recorded in an identification information data area. The identification information is included in the 2-dimensional code **42** (refer to FIG. **2**) printed on the paper **40**.

Data of a stereoscopic image that is displayed when the HMD **20** is worn by the right eye are stored in a stereoscopic image data area (right). Such data are used for stereoscopic viewing when the printed stereoscopic image **41** is viewed by the left eye, which in this example does not wear the HMD. In this way, stereoscopic viewing is made possible. In other words, when the HMD **20** is worn by the right eye, the viewing person sees the stereoscopic image displayed on the display unit **22** of the HMD **20** with the right eye, while seeing the stereoscopic image **41** (FIG. **2**) on the paper **40** with the left eye. In this way, stereoscopic viewing is made possible.

Similarly, stereoscopic image data that are displayed when the HMD **20** is worn by the left eye are stored in a stereoscopic image data area (left). In such case, the printed stereoscopic image **41** is viewed by the right eye, and stereoscopic viewing is made possible. In other words, when the HMD **20** is worn by the left eye, the viewing person sees the stereoscopic image displayed on the display unit **22** of the HMD **20** with the left eye, while seeing the stereoscopic image **41** (FIG. **2**) on the paper **40** with the right eye. In this way, stereoscopic viewing is made possible.

The viewing person wears the HMD **20** such that the display unit **22** is located in front of one of the eyes, as shown in FIG. **2**, and sees the stereoscopic image **41** on the paper **40** with the other eye. Here, on the paper **40**, the stereoscopic image **41** and the 2-dimensional code **42** are printed.

Next, descriptions about a method of stereoscopic viewing, i.e., the images to be seen by the left eye and the right eye, according to the present embodiment follow with reference to FIG. **3**. An actual relative position **45** is shown in FIG. **3**, wherein a viewing target is an apple and an orange placed on a table, and the viewing person stands on the right-hand side of the due front of the table. In this case, an image that the viewing person sees by the left eye is shown by a left eye image **46**, and an image seen by the right eye is shown by a right eye image **47**. Here, the parallax of the image between the left and the right eyes changes with the distance to the viewing target.

According to the present embodiment, stereoscopic viewing is provided by seeing the stereoscopic image **41** on the paper **40** by one eye, and seeing the image displayed on the display unit **22** of the HMD **20** by the other eye. For example, if the HMD **20** is worn for the left eye, the right eye sees the right eye image **47** serving as the stereoscopic image **41** on the paper **40**, and the left eye sees the left eye image **46** displayed on the display unit **22** of the HMD **20**.

An exemplary process of performing a stereoscopic viewing using the image display system is described with reference to FIG. **4**.

First, the stereoscopic image **41**, and the 2-dimensional code **42**, which contains the identification information, are printed on the paper **40**. The viewing person wears the HMD **20** for one of his/her eyes. Whether the HMD **20** is worn for the right eye or for the left eye is input to the input interface **28**, which information is stored in a storage unit (not illustrated) of the control unit **21**. For example, if the HMD **20** is worn for the left eye, "left" is input, and the control unit **21** stores information indicating that the wearing position is "left".

Then, the paper **40** is photographed with the camera **29**, while the viewing person looks at the paper **40** at the front as shown in FIG. **2** (Step S**1**-**1**). The 2-dimensional code recognition unit **24** of the control unit **21** reads the 2-dimensional code **42** in the photographed image (Step S**1**-**2**). Here, if the 2-dimensional code **42** is not recognized, the process returns to Step S**1**-**1**.

Then, the 2-dimensional code recognition unit **24** extracts the identification information from the 2-dimensional code **42**, and provides the identification information to the image downloading unit **25**; then, the image downloading unit **25** downloads a stereoscopic image specified by the identification information from the server **30** (Step S**1**-**3**). More specifically, the image downloading unit **25** transmits the identification information read from the 2-dimensional code **42**, and the information about the wearing position, whether "left" or "right", to the server **30**. That is, if the information indicating the wearing position is "left", that information is provided to the server **30** with the identification information. The server **30** identifies stereoscopic image data **310** based on the identification information, and the wearing position based on the information indicating the wearing position. Then, one of a stereoscopic image (right) and a stereoscopic image (left) is provided to the HMD **20** according to the wearing position, whether left or right. In the case of the present example, the stereoscopic image (left) is transmitted, and the display unit **22** of the HMD **20** shows the stereoscopic image (left).

Then, the viewing person performs a display position adjustment of the image being displayed on the HMD **20** (Step S**1**-**4**). More specifically, the viewing person operates the input interface **28** for carrying out projective transformation on the image being displayed on the display unit **22** such that positions of the stereoscopic image **41** on the paper **40** and the image on the display unit **22** agree. In this way, the stereoscopic view is obtained.

According to an embodiment of the present invention, the following effects are obtained.

(1) The first and the second view images are prepared taking parallax into consideration. More specifically, the first view image is the stereoscopic image **41**, which is a real image, printed on the paper **40** for one of the eyes to view; and the second view image is a virtual image displayed by the HMD **20** for the other eye to view. In this way, stereoscopic viewing is provided. Accordingly, the eye that looks at the real image is not covered by the HMD **20**, and the viewing person can keep awareness of the external world, and, for example, he/she can perform operations, and can perceive when a person is nearby, while performing stereoscopic viewing. Further, since the position of the image on the display unit **22** of the HMD **20** can be adjusted to agree with the position of the stereoscopic image **41** on the paper **40**, stereoscopic viewing that is flexible can be provided. In this way, flexible stereoscopic viewing, while keeping awareness to the external world by one of the eyes, is provided.

(2) The HMD **20** displays the image, which is a virtual image, by the display unit **22** based on the image photographed with the camera **29**. Stereoscopic viewing can be carried out using the 2-dimensional image, which is a virtual image, displayed based on the stereoscopic image **41** photographed with the camera **29**.

(3) The HMD **20** reads the image of the 2-dimensional code **42** printed on the paper **40**, the 2-dimensional code indicating an address, such as a URL, of the image of the virtual image, and displays the virtual image identified by the 2-dimensional code **42**. In this way, stereoscopic viewing is realized by using the data of the virtual image beforehand prepared, mitigating a processing load.

(4) The HMD **20** for displaying the virtual image is a head wearing type single eye display unit; for this reason, both hands of the viewing person are free.

(5) The position of the virtual image displayed on the HMD **20** can be adjusted by carrying out projective transformation. In this way, stereoscopic viewing is provided by properly positioning the virtual image displayed on the HMD **20** to agree with the real image, i.e., the stereoscopic image **41** on the paper **40**.

Second Embodiment

Hereafter, a second embodiment that realizes one or more aspects of the present invention is described with reference to FIGS. **5** through **11**. An image display system, an image display method, a coding method, and a printed matter **65** for stereoscopic viewing, according to the second embodiment, are described, whereby a viewing person obtains flexible stereoscopic viewing with one of the eyes being available for seeing the external world. The printed matter **65** for stereoscopic viewing (typically, paper) carries an image (the first view image) that is a real image, and a 2-dimensional code for generating an image (the second view image) to be displayed on a head mounting display HMD **50**. The first view image placed on the printed matter **65** for stereoscopic viewing is viewed by one of the eyes of the viewing person, while the second view image displayed on a display **52** of the HMD **50** is viewed by the other eye so that stereoscopic viewing is provided. Here, the second view image is generated by photographing the first view image and the 2-dimensional code on the printed matter **65**; and by carrying out the following process. That is, the printed matter for stereoscopic viewing constitutes a real image presentation unit in this embodiment. Further, the HMD **50** (a single eye head mount display) constitutes a virtual image presentation unit.

The printed matter **65** (printed paper) (FIG. **7**) is generated by a computer executing a printed matter generating program. Through execution of the program, an image to be printed is selected, contents of the 2-dimensional code are determined, and printing positions of one of a pair of stereoscopic images and the 2-dimensional code are determined.

Hereafter, a process of generating the printed matter **65** for stereoscopic viewing by the printed matter generating program is described. First, the printed matter generating program is started on a computer. Then, an image to be printed is selected. More specifically, the viewing person chooses a pair of stereoscopic images following directions displayed on the computer (Step S**2-1**). The pair of stereoscopic images, which images are beforehand stored in the computer, includes a stereoscopic image for the right eye, and a stereoscopic image for the left eye.

Next, the viewing person specifies a stereoscopic image to be printed, i.e., whether the stereoscopic image for the right eye or for the left eye is to be printed is selected; and the viewing person specifies a printing position (Step S**2-2**). More specifically, if the viewing person chooses to wear the HMD **50** for his/her right eye, the stereoscopic image for the left eye is to be printed. Further, the viewing person specifies the printing position of an image area **61** for the selected image in a printing area **60** displayed on the computer (FIG. **7**). For example, as shown in FIG. **7**, the position of the image area **61** is specified in the printing area **60**.

Then, a position of a 2-dimensional code area **62** for printing the 2-dimensional code is specified (Step S**2-3**). More specifically, the viewing person specifies the position of the 2-dimensional code area **62** following directions displayed on the computer. Here, according to the present embodiment, the 2-dimensional code area **62** is a square, which area should not be overlapped with the image area **61**. For example, the position of the 2-dimensional code area **62** is specified as shown in FIG. **7**.

If the position of the 2-dimensional code area **62** is specified, the computer generates the 2-dimensional code (Step S**2-4**) as described in detail in the following.

First, ratios of lengths of sides of the 2-dimensional code area **62** and the image area **61** are determined. In the present example, the lengths of the sides of the image area **61** are 4 times as great as the lengths of the sides of the 2-dimensional code area **62**.

Next, a position relation between the image area **61** and the 2-dimensional code area **62** is determined. In this example, the position relation is defined by a relative position of the lower left corner of the 2-dimensional code area **62** to the lower right corner of the image area **61** as indicated by an arrow in FIG. **7**. For example, the relative position of the former can be expressed by (1, 1), where "1", serving as a unit length, represents the length of the side of the 2-dimensional code area. Then, with reference to FIG. **8**, differences between a stereoscopic image **70** (for the left eye in this example) printed in the image area **61** and a stereoscopic image **71** (for the right eye) that is not printed in the image area **61** are computed to generate a difference image **72**. Here, the stereoscopic image **70** represents the whole image printed in the image area **61**, and the stereoscopic images **70** and **71** are constituted by 16 pixels (4 lines×4 columns). That is, a very coarse image is assumed for describing purposes.

The stereoscopic image **70** and the stereoscopic image **71** are expressed as 16-bit images in FIG. **8**. Differences between corresponding pixels of the stereoscopic image **70** and the stereoscopic image **71** are given by the difference image **72**. A numeric sequence is generated based on pixel values of the difference image **72**; namely, a sequence (0, −1, 1, 0, −1, 0, −1, −2, 2, 4, 5, 4, 0, −1, 0, −1) is generated.

The information including the ratios of the lengths of the sides of the 2-dimensional code, the relative position, the difference information (coded information of the differences) described above is coded into the 2-dimensional code, and a 2-dimensional code image is generated. In the case of the present example, the 2-dimensional code image includes information (4, 4, 1, 1, 0, −1, 1, 0, −1, 0, −1, −2, 2, 4, 5, 4, 0, −1, 0, −1), the first two numbers representing the ratios, the next two numbers representing the relative position, and the rest representing the difference image **72**. The 2-dimensional code image is printed at the 2-dimensional code area **62**. Here, when the number of elements to be coded is great, because finer resolution and gradation of an image are required, data compression may be carried out using for example a Huffman encoding method and a box coding (a 2-dimensional coding) of Longsalt Systems.

When the above process is completed, the viewing person inputs printing directions to the computer such that an image that is similar to the image in the printing area **60** is printed on the paper **65** by a printing machine.

Next, a process of performing stereoscopic viewing using the paper **65** is described. First, the configuration of the image display system according to the second embodiment is described with reference to FIG. **5**.

The head mount display HMD **50** for a single eye includes a control unit **51** that is connected to the display **52**. The control unit **51** includes CPU, RAM, and ROM (not illustrated), and carries out steps described below. The control unit **51** includes a display content change unit **53**, a 2-dimensional code recognition unit **54**, an image restoration unit **55**, and a relative position measuring unit **56**, all of which carry out assigned functions by executing a program.

The display content change unit **53** adjusts the image displayed on the display **52** by performing projective transformation on display data of the image based on the relative position between the HMD **50** and the paper **65**. Further, the display content change unit **53** performs the projective transformation on the display data of the image displayed on the display **52** according to an operation by the viewing person of an input interface **58**, the viewing person selecting a state of the display data. Further, the display content change unit **53** automatically performs the projective transformation on the display data based on an amount of adjustment selected by the viewing person and the relative position of the HMD **50** to the paper **65**.

The 2-dimensional code recognition unit **54** determines whether there is a 2-dimensional code present in the image that is photographed with the video camera **59**. If the determination is affirmative, the 2-dimensional code recognition unit **54** decodes the 2-dimensional code. The image restoration unit **55** restores another stereoscopic image based on the difference image information that is decoded and the stereoscopic image photographed with the video camera **59**.

The relative position measuring unit **56** determines the relative position (such as distance, direction, and inclination) between the HMD **50** and the paper **65** based on the 2-dimensional code **67** photographed with the video camera **59**. That is, the relative position is acquired using the 2-dimensional code **67**, the video camera **59**, and the relative position measuring unit **56**.

The display **52** is for displaying information processed and output by the control unit **51**.

Further, the control unit **51** is connected to the video camera **59** serving as an image pick-up unit. The video camera **59** continuously takes images of the paper **65** (FIG. **7**) through a lens. The video camera **59** is arranged such that the photographing plane is parallel to the display **52**, and the center of the optical axis agrees with the center of the display **52**. The image photographed with the video camera **59** is transmitted to the control unit **51**.

Further, the control unit **51** is connected to the input interface **58**. The input interface **58** includes a pointing device, such as a mouse, for adjusting the image being displayed on the display **52**.

The following description is about an exemplary process of performing stereoscopic viewing using the image display system, wherein FIGS. **9** through **11** are referenced.

The viewing person wears the HMD **50** like the case of the first embodiment, and faces the paper **65**. Then, the video camera **59** takes a stereoscopic image **66** and the 2-dimensional code **67** printed on the paper **65** (Step S**3-1**). The video camera **59** transmits the photographed video image to the control unit **51**. The 2-dimensional code recognition unit **54** of the control unit **51** recognizes the video image (Step S**3-2**).

Here, the process carried out by the 2-dimensional code recognition unit **54** is described.

The 2-dimensional code recognition unit **54** decodes the 2-dimensional code and recognizes the stereoscopic image **66**. More specifically, the perimeter of the 2-dimensional code **67** is first recognized from the image in every frame photographed with the video camera **59**, and tilt is compensated for. According to the present embodiment, the 2-dimensional code **67** is shaped square; therefore, the tilt can be easily compensated for by recognizing four angles of the 2-dimensional code. Then, the image, for which the tilt has been compensated for is superposed on a tilt compensated superposed image **76** (FIG. **11**).

The tilt compensated superposed image **76** is described with reference to examples given in FIG. **10**, which drawing shows a part of a first frame **73**, a part of a second frame **74**, and a part of a superposed image **75**. The part of the first frame **73** is the part of the image of the first frame photographed with the video camera **59**, to which image, the tilt compensation has been carried out. The part of the second frame **74** is the part of the image of the second frame photographed with the video camera **59**, to which image, the tilt compensation has been carried out. The part of the superposed image **75** is the part of the tilt compensated superposed image based on the image of the first frame and the image of the second frame. That is, each pixel of the tilt compensated superposed image represents a total of values of the pixels of the first through the k-th frames.

Next, 2-dimensional code recognition is performed using the tilt compensated superposed image **76**. A portion wherein the 2-dimensional code **78** is present in the tilt compensated superposed image **76** is binarized, and the 2-dimensional code is extracted. Then, the 2-dimensional code is decoded, and 2-dimensional code information is acquired. According to the example above, the 2-dimensional code information, which is a numerical sequence of (4, 4, 1, 1, 0, −1, 1, 0, −1, 0, −1, −2, 2, 4, 5, 4, 0, −1, 0, −1) is acquired. If one of or both the recognition of the 2-dimensional code **67** and photographing of the image is not properly performed (NO at Step S**3-2**), the process returns to Step S**3-1**.

If the 2-dimensional code **67** is successfully recognized and a video image is successfully photographed ("YES" at Step S**3-2**), the stereoscopic image is restored (Step S**3-3**). More specifically, an estimated stereoscopic image area **77** is first obtained from the 2-dimensional code information. Here, the values of the first, the second, the third, and the fourth elements of the 2-dimensional code information provide the ratio of the lengths of the sides of the 2-dimensional code, and the relative position. Accordingly, the estimated stereoscopic image area **77** relative to the position of the 2-dimensional code (a 2-dimensional code area **78**) can be determined.

Subsequent elements of the 2-dimensional code information, namely, the fifth, the sixth, and so on to the k-th elements, are the difference information.

According to the above example, the 2-dimensional code includes the first to the 20th elements, wherein the difference information is comprised by 16 elements, namely, from the fifth to the 20th elements. Further, because the first and the second elements are (4, 4), the 16 elements are determined to configure a matrix of four lines×four sequences.

In another example, the first and the second elements of the 2-dimensional code information are (4, 3), and 12 elements from the fifth to the 16th elements may be provided. Then, the 12 elements are determined to constitute a matrix of 4×3. Further, in another example, the first and the second elements of the 2-dimensional code information are (8, 6), and 48 elements (from the fifth to the 52nd elements) may be provided. The 48 elements represent the difference information of an 8×6 matrix. That is, the numerical sequence (the 2-dimensional code information) is a single-dimensional expression of the matrix.

Referring again to the first example, wherein the numerical sequence is a single-dimensional expression of a 4×4 matrix, the 2-dimensional code information is converted into the 4×4 matrix, and the difference image **72** is restored. Further, the estimated stereoscopic image area **77** is divided into a 4×4 matrix. Then, the difference image **72** is added to the stereoscopic image **70** provided in the estimated stereoscopic image area **77**, the added result being the stereoscopic image **71**.

Then, projective transformation is carried out on the stereoscopic image **71** according to the relative position between the paper **65** and HMD **50**. More specifically, the four corners of the 2-dimensional code photographed with the video camera **59** are recognized, projective transformation is carried out on the 2-dimensional code **78** on the compensation superposed image **76** according to this to agree with the recognized four corners, and projective transformation is similarly carried out on the stereoscopic image **71** in the estimated stereoscopic image area **77** of the compensation superposed image **76**. Then, the stereoscopic image **71**, on which the projective transformation has been carried out, is displayed on the display **52** of the HMD **50**. Here, if an amount of adjustment at the time of the completion of adjustment (described below) is stored in a storage unit (not illustrated) in the display content change unit **53** of the HMD **50**, the display content change unit **53** carries out projective transformation on the stereoscopic image **71** using the amount of adjustment, and displays the image after adjustment on the display **52**.

Further, if necessary or desired, the viewing person can adjust the display position (Step S**3-4**). More specifically, the viewing person inputs a direction concerning the projective transformation of the image being displayed on the display **52** using the input interface **58**. According to the direction, the display content change unit **53** carries out projective transformation on the image being displayed on the display **52**. When the position adjustment of the image is completed, that is, if stereoscopic viewing is obtained, the viewing person inputs a direction that the adjustment is completed to the input interface **58** (Step S**3-5**). The control unit **51** of the HMD **50** stores the amount of adjustment at the time of the completion of the adjustment in the storage unit (not illustrated) of the display content change unit **53**. In addition, the amount of tilt is measured by the 2-dimensional code recognition unit **54** in the meantime.

The relative position (position and inclination) between the paper **65** and the HMD **50** is specified by measuring the amount of tilt, and based on the relative position (position and inclination) of the HMD **50** to the paper **65** at the time of the completion of adjustment, wherein the distance between the paper **65** and HMD **50** when the adjustment is completed is made into 1 (serves as the reference). Then, based on the relative position (position and inclination) of the HMD **50** to the paper **65** at the time of the completion of adjustment, the display content change unit **53** of HMD **50** automatically adjusts the display position, and the like, of the image (Step S3-**6**). In this way, henceforth, the viewing person can view a stereoscopic image without having to adjust the display position, and the like.

According to an embodiment of the invention, the following effects are obtained in addition to one or more of the effects described above.

(6) The HMD **50** displays the virtual image that is generated by adding the real image and the 2-dimensional code **67** that contains the data representing differences from the stereoscopic image **66** on the paper **65** photographed with the video camera **59**, i.e., the differences between the images for the right and left eyes. In this way, the data for showing the virtual image is not beforehand required, but the virtual image can be generated using the photographed image.

(7) The 2-dimensional code **67** includes the coded data about the differences between the images viewed by the two eyes, and the coded data about the relative position and relative size of the 2-dimensional code **67** to the stereoscopic image **66** shown as the real image. Accordingly, the information about the relative position and relative size of the 2-dimensional code **67** to the stereoscopic image **66** shown as the real image, and the difference data can be acquired from the 2-dimensional code **67**. In this way, the image to be displayed by the HMD **50** can be generated from the stereoscopic image **66** that is photographed, and the 2-dimensional code **67**.

(8) The relative position of the HMD **50** to the paper **65** is determined by the 2-dimensional code **67**, the video camera **59**, and the relative position measuring unit **56**. In this way, the virtual image can be displayed using the determined relative position.

(9) The relative position can be determined using the image that is photographed with the video camera **59** of the HMD **50**.

(10) The projective transformation based on the determined relative position is carried out on the display data of the image shown by the HMD **50**. In this way, the image (virtual image) displayed on the HMD **50** is adjusted according to the relative position between the paper **65** and the HMD **50**.

(11) By an operation of the viewing person, the projective transformation can be carried out on the display data of the image (the second view image) on which the projective transformation based on the relative position has been carried out, the viewing person selecting a state of the display data. In this way, the virtual image displayed on the HMD **50** can be adjusted by the operation of the viewing person according to an individual difference, such as an angle, due to a personal physical feature.

(12) The projective transformation is carried out on the display data of the image (the second view image) displayed on the HMD **50** based on the information (the amount of adjustment) according to the viewing person's selection, and based on the relative position. That is, the projective transformation is carried out considering the individual difference, such as the congestion angle, due to the personal physical feature, and the relative position. At the same time, the image (the second view image) displayed on the HMD **50** can be automatically adjusted to agree with the stereoscopic image **66** (real image) on the paper **65** such that stereoscopic viewing is possible according to the relative position.

(13) The 2-dimensional code **67** includes the information about the relative position and relative size of the stereoscopic image **66** and the 2-dimensional code **67** that is provided on the paper **65** with the stereoscopic image **66**. Accordingly, the position and size of the stereoscopic image **66** can be determined by reading the information included in the 2-dimensional code **67**.

Third Embodiment

Hereafter, a third embodiment that realizes one or more aspects of the present invention is described with reference to FIGS. **12** through **14**. Descriptions follow about an image display system, an image display method, a coding method, and a printed matter **85** for stereoscopic viewing according to the third embodiment, wherein the viewing person can perceive the external world with one of the two eyes. With this embodiment, a first view image and a 2-dimensional code are printed on the printed matter **85** (typically, paper **85**), wherein the 2-dimensional code is for generating a second view image to be displayed on a single eye head mount display HMD **50** such that a part of the image is stereoscopically shown in a different depth position (i.e., 3-dimensionally with an elevation) using parallax. More specifically, the first view image on the printed matter **85** is viewed with one eye of the viewing person, and the second view image displayed on the display **52** of the HMD **50** is viewed by the other eye. Then, the part of the image is stereoscopically viewed with the different depth position. In other words, the part is seen with unevenness (an elevation). The printed matter for stereoscopic viewing serves as a real image presentation unit, and the single eye head mount display HMD **50** serves as a virtual image presentation unit. According to the third embodiment, a map is used as the image, a part of which is made visible with the different depth position (i.e., with an elevation); however, this is for example only, and the present invention can be applied to other objects.

First, the printed matter **85** is prepared as follows (refer to FIG. **13**). The computer executes a second printed matter generating program for determining contents of the 2-dimensional code, the position of the selected image, the position of the portion of the image for stereoscopic display, and the position of the 2-dimensional code.

An exemplary process of preparing the printed matter **85** is described with reference to FIG. **12**.

The second printed matter generating program is started at the computer, and then the viewing person specifies an image wherein an elevation is made to be visible (Step S4-**1**). Here, it is assumed that a map image shown in a stereoscopic image area **81** shown in FIG. **13** is specified. Next, a position of the image in the printing area is specified (Step S4-**2**). That is, the stereoscopic image area **81** is specified. Next, a position of the 2-dimensional code is specified (Step S4-**3**). That is, the viewing person specifies a 2-dimensional code area **82**.

Next, the 2-dimensional code is generated (Step S4-**4**) as follows.

First, the viewing person specifies the position and size of the part that is to be stereoscopically shown in the stereoscopic image area **81**. More specifically, according to the system of coordinates given in an upper part of FIG. **13**, for example, a coordinate (8, 1) and a size 2 are input; a coordinate (8, 11) and a size 2 are input; and an appending message, e.g., "convenience stores", is input.

Then, the computer computes a ratio of lengths of the sides of the 2-dimensional code area **82** and the stereoscopic image area **81**. In this example, the vertical length and the horizontal length of the stereoscopic image area **81** are 12 times as long as the vertical length and the horizontal length, respectively, of the 2-dimensional code area **82**. Next, the relative position between the stereoscopic image area **81** and the 2-dimensional code area **82** is determined. More specifically, the relative position between the lower right corner of the stereoscopic image area **81** and the lower left corner of the 2-dimensional code area **82**, as indicated by an arrow of a dotted line in FIG. **13**, is measured. In this example, the relative position can be expressed by (10, 2), wherein the length of a side of the 2-dimensional code area serves as the unit length.

The above information, namely, the ratios of the vertical and horizontal lengths between the stereoscopic image area **81** and the 2-dimensional code, the relative position, and position code data (8, 1, 2, 8, 11, 2, convenience store) that are input by the viewing person are appended. As a result, the 2-dimensional code including (12, 12, 10, 2, 8, 1, 2, 8, 11, 2, convenience store) is generated. The 2-dimensional code is made into the 2-dimensional code image, and the image is transposed to the 2-dimensional code area **82**. Here, if a great number of data elements have to be coded due to, e.g., the size of difference image being large and gradation of the image being required, data compression by the Huffman coding or the box coding (2-dimensional coding) of Longsalt Systems may be used.

If necessary or desired, the printing area is edited (Step S**4**-**5**). When a printing direction is issued, an image similar to the printing area **80** is printed by a printing machine, and the paper **85** is output. Here, the paper **85** as shown in FIG. **13** is printed. In the paper **85**, a map image **86**, a 2-dimensional code **87**, and characters that may have been edited as desired, e.g., "convenience stores" are arranged.

Next, stereoscopic viewing using the paper **85** is described. Where the structure of the system according to the third embodiment is the same as the second embodiment, descriptions are not repeated.

Hereafter, an exemplary process of stereoscopic viewing is described with reference to FIG. **14**.

First, the viewing person wears the HMD **50** as shown in FIG. **2** as in the first and the second embodiments above. Here, it is assumed that he/she wears the HMD **50** for the right eye, which fact is input to the input interface **58**. The control unit **51** of the HMD **50** stores data indicating that the viewing person wears the HMD **50** for the "right" eye in the storage unit (not illustrated) of the control unit **51**. Then, the viewing person views the paper **85**; and the map image **86** and the 2-dimensional code **87** printed on the paper **85** are photographed by the video camera **59** (Step S**5**-**1**). Then, the 2-dimensional code recognition unit **54** of HMD **50** recognizes the photographed video image (Step S**5**-**2**) in the same way as in the second embodiment. In this way, according to the example, a restoration result (12, 12, 10, 2, 8, 1, 2, 8, 11, 2, convenience store) is obtained from the 2-dimensional code **87**. In addition, if one of or both the recognition of the 2-dimensional code **87** and photographing of the video image is not properly performed ("NO" at Step S**5**-**2**), the process returns to step S**5**-**1**.

When the 2-dimensional code **87** can be recognized and photographing of the video image are properly performed ("YES" at Step S**5**-**2**), the stereoscopic image is restored (Step S**5**-**3**). More specifically, the map image area is first determined by the same method as determining the stereoscopic image area in the second embodiment. Then, a specific partial move image is generated to (8, 1) and (8, 11) of the determined map image area, the specific partial move image being an image having pixels shifted to the left by a predetermined quantity, for example, a magnitude of 2. Here, the direction of moving the portion that is to be shown with the elevation using parallax is determined based on the data stored as the wearing position. That is, in this example, "right" has been stored as the wearing position; accordingly, the image is moved to the left.

Then, projective transformation is carried out on the image to be displayed on the HMD **50** according to the relative position between the paper **85** and the HMD **50**. More specifically, four corners of the 2-dimensional code photographed with the video camera **59** are recognized, projective transformation is carried out on the 2-dimensional code of the tilt compensation superposed image in accordance with this, and projective transformation is similarly carried out on the generated specific partial move image. Then, the specific partial move image, on which projective transformation has been carried out, is displayed on the display **52** of the HMD **50**. Here, if an amount of adjustment at the time of the completion of the adjustment (described below) is stored in the storage unit (not illustrated) of the display content change unit **53** of the HMD **50**, the display content change unit **53** is further adjusted by carrying out projective transformation on the specific partial move image using the amount of adjustment at the time of the completion of the adjustment, and an image after the adjustment is displayed on the display **52**.

If necessary or desired, display position adjustment may be carried out by the viewing person (Step S**5**-**4**). When the viewing person obtains a position that provides stereoscopic viewing, a direction of completion of adjustment is input to the input interface **58** (Step S**5**-**5**). The control unit **51** of the HMD **50** stores the amount of the adjustment at the time of the completion of the adjustment in the storage unit (not illustrated) of the display content change unit **53**. Here, an amount of tilt is measured by the 2-dimensional code recognition unit **54** in the meantime. By using the measured amount of tilt, the relative position (the position and inclination) between the paper **85** and the HMD **50** at the time of the completion of adjustment is specified, wherein the relative distance between the paper **85** and the HMD **50** at the time of the completion of adjustment is made into 1, serving as the reference value. Then, based on the relative position (the position and inclination) of HMD **50** at the time of the completion of adjustment, the display content change unit **53** of the HMD **50** automatically adjusts the display position of an image (Step S**5**-**6**). Here, the process of steps S**5**-**4** through S**5**-**6** is performed like the steps S**3**-**4** through S**3**-**6** of the second embodiment.

According to an embodiment of the invention, the following effects are obtained in addition to one or more of the effects described above.

(14) The 2-dimensional code **87** includes information about the position on the portion that is to be displayed with elevation in the map image **86** using parallax. Therein, the map image **86** and the 2-dimensional code **87** are photographed, and the position information on the portion that is to be displayed with elevation using the parallax in the map image **86** is acquired from the 2-dimensional code **87**. In this way, the image to be displayed on the HMD **50** so that the part of the map image **86** can be viewed with elevation using parallax can be generated using the photographed image without beforehand preparing the data of the image for displaying on the HMD **50**.

Fourth Embodiment

Hereafter, a fourth embodiment that realizes one or more aspects of the present invention is described with reference to FIGS. **15** through **17**. In the following, an image display system and an image display method of flexible stereoscopic viewing are described, wherein the viewing person can view the external world with one of the two eyes. According to the fourth embodiment, stereoscopic viewing is available at multiple points with a first view image displayed on a multiaspect stereo display **100** that shows different images according to viewing positions, and a second view image displayed on the display of a single eye head mount display HMD **90**. That is, the multiaspect stereo display constitutes a real image presentation unit, and the single eye head mount display constitutes a virtual image presentation unit.

As shown in FIG. **15**, the single eye head mount display HMD **90** includes a control unit **91**, and a display **92** connected to the control unit **91**. The control unit **91** includes CPU, RAM, and ROM (not illustrated), and executes a process that is described below. The control unit **91** includes a display content change unit **93**, a relative position measuring unit **94**, and an image downloading unit **95**, which function according to a program for the process.

The display content change unit **93** adjusts an image to be displayed on the display **92** by carrying out projective transformation on display data of the image. That is, the display content change unit **93** functions as a display data deformation unit for carrying out projective transformation to the display data of the image based on the relative position of the HMD **90** and the multiaspect stereo display **100**. Further, the display content change unit **93** functions as a display data status selection unit for carrying out projective transformation on the image displayed on the display **92** by an operation of the viewing person, and prompting the viewing person to choose the state of the display data. Further, the display content change unit **93** functions as a display data automatic deformation unit for automatically carrying out projective transformation on display data based on the amount of adjustment by the viewing person's selection, and the relative position between the multiaspect stereo display **100** and the HMD **90**.

The relative position measuring unit **94** determines the relative position (relative relation about distance, direction, and inclination) of the HMD **90** to the multiaspect stereo display **100** by receiving an ultrasonic wave transmitted by ultrasonic loudspeakers **102**, **103**, and **104** of the multiaspect stereo display **100** with ultrasonic microphones **97** and **98** attached to the HMD **90**. That is, the ultrasonic loudspeakers **102**, **103**, and **104**, the ultrasonic microphones **97** and **98**, and the relative position measuring unit **94** function as a relative position specification unit.

The image downloading unit **95** downloads an image to be displayed on the HMD **90** from the multiaspect stereo display **100**.

The display **92** displays information processed and output by the control unit **91**.

Further, the ultrasonic microphones **97** and **98** attached to the HMD **90** are connected to the control unit **91**. The ultrasonic microphones **97** and **98** receive ultrasonic waves transmitted by the ultrasonic loudspeakers **102**, **103**, and **104** of the multiaspect stereo display **100**.

Further, the control unit **91** is connected to an input interface **96**. The input interface **96** includes a pointing device, such as a mouse, for adjusting an image displayed on the display **92**.

Here, the HMD **90** may be connected to the multiaspect stereo display **100** by a cable or radio. The multiaspect stereo display **100** includes a control unit **101** that is connected to the control unit **101**, the ultrasonic loudspeakers **102**, **103**, and **104**, the display **105**, and an image folder **106**.

The control unit **101** includes CPU, RAM, ROM, and a hard disk, which are not illustrated, and perform a process as described below.

The ultrasonic loudspeakers **102**, **103**, and **104** generate ultrasonic waves having different wavelengths. The ultrasonic loudspeaker **102** is located at a lower left corner of the front unit of the multiaspect stereo display **100** as shown in FIG. **16**. The ultrasonic loudspeaker **103** is located at an upper left corner of the front unit of the multiaspect stereo display **100**, and is located on the vertical line of the ultrasonic loudspeaker **102**. The ultrasonic loudspeaker **104** is located at a lower right corner of the front unit of the multiaspect stereo display **100**, and is located on the horizontal line of the ultrasonic loudspeaker **102**.

The display **105** displays an image stored in the image folder **106**. The image displayed by the display **105** of the multiaspect stereo display **100** is differently viewed by different positions of viewing persons. For example, as shown in FIG. **16**, a first viewing person in a position A sees an image a**1**; a second viewing person in a position B sees an image b**1**; and a third viewing person in a position C sees an image c**1**. Further, the HMD **90** of the first viewing person shows an image a**2**; the HMD **90** of the second viewing person shows an image b**2**; and the HMD **90** of the third viewing person shows an image c**2**. Here, the images a**1** and a**2** constitute a stereoscopic image pair; the images b**1** and b**2** constitute a stereoscopic image pair; and the images c**1** and c**2** constitute a stereoscopic image pair. In this way, the viewing persons can see a 3-dimensional moving picture even though they are located at the different positions. More specifically, for example, in the case of the first viewing person, the image a**1** displayed on the display **105** is viewed by one eye, and the image a**2** displayed on the display **92** of the HMD **90** is viewed by the other eye. In addition, these images are stored in the image folder **106** of the multiaspect stereo display **100**, taking a synchronization.

As in the first through the third embodiments, the viewing person wears the HMD **90** such that the display **92** can be viewed with one eye, and the multiaspect stereo display **100** is seen in this state with the other eye.

The process of viewing the 3-dimensional moving picture using the image display system constituted as described above is described with reference to FIG. **17**.

First, the viewing person wears the HMD **90**. The ultrasonic microphones **97** and **98** of the HMD **90** receive the ultrasonic waves of different frequencies transmitted by the ultrasonic loudspeakers **102**, **103**, and **104** of the multiaspect stereo display **100**. Based on the received ultrasonic waves, the relative position measuring unit **94** acquires the relative position between the HMD **90** and each of the ultrasonic loudspeakers **102**, **103**, and **104** (Step S**6**-**1**).

Then, the HMD **90** downloads an image (Step S**6**-**2**). More specifically, HMD **90** first transmits data about the acquired relative position to the multiaspect stereo display **100**. The multiaspect stereo display **100** distinguishes whether the position of the HMD **90** is in the position A, the position B, or the position C based on the relative position between the HMD **90** and each of the ultrasonic loudspeakers **102**, **103**, and **104**. Then, a stereoscopic image in sync with the image that is displayed on the display **105** and can be viewed at the distinguished position is transmitted to the HMD **90** frame by frame. For example, if the viewing person is in the position A, he/she views the image a**1** on the multiaspect stereo display **100**; accordingly, the multiaspect stereo display **100** continuously transmits frames of the image a**2** that is in sync with the image a**1** and constitutes the stereoscopic image pair with the image a**1** to the HMD **90** such that the image a**2** is displayed on the display **92**. In addition, the relative position is determined, and when the viewing person moves, e.g., to the position B from the position A, the multiaspect stereo display **100** changes the image to be transmitted from the image a**2** to the image b**2**.

The HMD **90** determines the relative position (relation of distance, direction, and inclination) between the multiaspect stereo display **100** and the HMD **90** based on the ultrasonic waves received from the ultrasonic loudspeakers **102**, **103**, and **104**, and carries out projective transformation on the image received based on this. Then, the image on which the projective transformation has been carried out is displayed on the display **92** of the HMD **90**. Here, when the amount of adjustment at the time of the completion of adjustment as described below is stored in a storage unit (not illustrated) of the display content change unit **93** of the HMD **90**, the display content change unit **93** may further carry out projective transformation on the image using the amount of adjustment at the time of the completion of adjustment, and such adjusted image is displayed on the display **92**.

Further, if necessary or desired, the viewing person may adjust the display position (Step S**6**-**3**). More specifically, the viewing person inputs directions of projective transformation about the image being displayed on the display **92** using the input interface **96**. Then, the display content change unit **93** carries out projective transformation on the image displayed on the display **92** according to the directions. Further, the viewing person inputs directions of the completion of adjustment to the input interface **96**, if the image is in the position that gives stereoscopic viewing (Step S**6**-**4**). The control unit **91** of the HMD **90** stores the amount of adjustment at the time of the completion of adjustment in the storage (not illustrated) of the display content change unit **93**.

Afterward, the relative position (the position and inclination) between the multiaspect stereo display **100** and the HMD **90** is determined with reference to the relative position of the HMD **90** at time of the completion of the adjustment, the reference relative position being normalized as 1.

Then, based on the relative position (the position and inclination) of the HMD **90** at the time of the completion of adjustment, the display content change unit **93** of the HMD **90** automatically adjusts the display position of the image (Step S**6**-**5**). In this way, the viewing person henceforth can see a stereoscopic image without having to adjust the display position, and the like.

According to an embodiment of the present invention, the following effects are obtained in addition to one or more of the effects described above.

(15) The relative position between the HMD **90** and the multiaspect stereo display **100** is determined by the ultrasonic loudspeakers **102**, **103**, and **104**, the ultrasonic microphones **97** and **98**, and the relative position measuring unit **94**. In this manner, a virtual image can be shown using the determined relative position.

(16) The multiaspect stereo display **100** presents two or more images (such as the images a**1**, b**1**, and c**1**) corresponding to the positions of the viewing persons as a real image, and the HMD **90** presents the virtual image (such as the images a**2**, b**2**, and c**2**) corresponding to the real image shown on the multiaspect stereo display **100**. In this way, simultaneous stereoscopic viewing is made possible at the different positions using the different real images and different virtual images according to the positions. For example, if two or more images (such as the images a**1**, b**1**, and c**1**) displayed on the multiaspect stereo display **100** are of the same object from different directions, stereoscopic viewing can be provided to two or more viewing persons located in different positions. Further, when using two or more images (such as the images a**1**, b**1**, and c**1**) that are of the same object from different directions, stereoscopic viewing can be provided even if a viewing person moves, e.g., to the position B from the position A.

Fifth Embodiment

Hereafter, a fifth embodiment that realizes one or more aspects of the present invention is described with reference to FIGS. **18** through **21**. An image display system and an image display method for providing flexible stereoscopic viewing are described, wherein one of the two eyes is available for seeing the external world. According to the fifth embodiment, stereoscopic viewing is provided by a first view image on a display **120** for displaying a different image according to a viewing position, and a second view image displayed on a display **112** of a single eye head mount display HMD **110**. That is, the display constitutes a real image presentation unit and the single eye head mount display constitutes a virtual image presentation unit. Here, the description is made for the case wherein the single eye head mount display HMD **110** is worn for the left eye.

The single eye head mount display HMD **110** includes a control unit **111** that is connected to the display **112** as shown in FIG. **18**. The control unit **111** includes CPU, RAM, and ROM (not illustrated), and performs a process that is described below.

The control unit **111** includes a virtual right eye position moving unit **113**, and an image downloading unit **114** that carry out the process according to a program.

The virtual right eye position moving unit **113** carries out a parallel movement of the position of a virtual right eye **132** (refer to FIG. **21**).

The image downloading unit **114** downloads a virtual HMD image to be displayed on the HMD **110** from the display **120**.

The display **112** displays information that is processed and output by the control unit **111**.

Further, ultrasonic loudspeakers **117**, and **118** are mounted on the HMD **110**, and are connected to the control unit **111**. The ultrasonic loudspeakers **117**, and **118** generate ultrasonic waves of different wavelengths. When wearing the HMD **110**, the viewing person makes a direction of a visual line of the left eye that wears the HMD **110** to be perpendicular to a line constituted by the ultrasonic loudspeaker **117** and the ultrasonic loudspeaker **118**; and a line constituted by the left eye and right eye of the viewing person to be parallel with the line constituted by the ultrasonic loudspeaker **117** and the ultrasonic loudspeaker **118**.

Further, an input interface **116** is connected to the control unit **111**. The input interface **116** includes a pointing device, such as a mouse, for adjusting an image being displayed on the display **112**.

Here, the HMD **110** may be connected to the display **120** by a cable or radio. The display **120** includes a control unit **121** that is connected to ultrasonic microphones **122**, **123**, **124**, a display unit **125**, and a 3-dimensional data storing unit **126**.

The control unit **121** includes CPU, RAM, ROM, and a hard disk (not illustrated) for carrying out a process that is described below. The control unit **121** includes a relative position measuring unit **127**, and a display image generation unit **128** that carry out the process by a program.

The relative position measuring unit **127** determines the relative position (distance, direction, and inclination) of the HMD **110** to the display **120** by the ultrasonic microphones

122, 123, and 124 receiving the ultrasonic waves transmitted by the ultrasonic loudspeakers 117, and 118. That is, the ultrasonic loudspeakers 117, and 118, the ultrasonic microphones 122, 123, and 124, and the relative position measuring unit 127 function as a relative position specification.

The display image generation unit 128 generates a virtual HMD image, and a virtual display image to be displayed on the display 112, and the display unit 125, respectively, from the 3-dimensional data stored in the 3-dimensional data storing unit 126 and based on the relative position information acquired by the relative position measuring unit 127.

The ultrasonic microphones 122, 123, and 124 are for receiving ultrasonic waves, and receive the ultrasonic waves transmitted by the ultrasonic loudspeakers 117, and 118 of the HMD 110 according to the present embodiment. The ultrasonic microphone 122 is located at a lower left corner of the front unit of the display 120 as shown FIG. 19. The ultrasonic microphone 123 is located at an upper left corner of the front unit of the display 120, and is located on the vertical line of the ultrasonic microphone 122. The ultrasonic microphone 124 is located at a lower right corner of the front unit of the display 120, and is located on the horizontal line of the ultrasonic microphone 122.

The display unit 125 displays the virtual display image generated by the display image generation unit 128.

The 3-dimensional data storing unit 126 stores the 3-dimensional data for generating the images to be displayed on the display 112 and the display unit 125. Here, according to the present embodiment, the 3-dimensional data are beforehand stored in the 3-dimensional data storing unit 126, wherein operations such as storing and exchanging of 3-dimensional data stored in the 3-dimensional data storing unit 126 may be performed by an interface (not illustrated). Further, as the 3-dimensional data, data generated by general 3-dimensional description languages, such as VRML, are used.

In the same way as in the first through the fourth embodiments, the viewing person wears the HMD 110 so that the display 112 is located in front of one of the eyes, the other eye viewing the display 120.

An exemplary process of stereoscopic viewing a 3-dimensional image using the image display system is described with reference to FIG. 20.

First, the viewing person wears the HMD 110 as described above. The ultrasonic microphones 122, 123, and 124 attached to the display 120 receive the ultrasonic waves of different frequencies transmitted by the ultrasonic loudspeakers 117, and 118 attached to the HMD 110. Based on this, the relative position measuring unit 127 computes the relative position of the HMD 110 from a reference point (Step S7-1). Here, a center position of the screen of the display unit 125 of the display 120 is made into the reference point according to the present embodiment.

Then, the HMD 110 downloads the virtual HMD image generated by the display image generation unit 128 of the display 120, and displays it on the display 112 (Step S7-2). On the other hand, the display 120 synchronously displays the virtual display image generated by the display image generation unit 128 on the display unit 125.

In the following, a process of generating the virtual display image and the virtual HMD image by the display image generation unit 128 is described referring to FIG. 21. The display image generation unit 128 arranges a virtual 3-dimensional object by 3-dimensional data, a virtual left eye 131, and a virtual right eye 132 in a virtual space (refer to (b) of FIG. 21), and generates the virtual display image and the virtual HMD image based on relative positions between these items. By this process, the virtual 3-dimensional object based on the 3-dimensional data is arranged at a position corresponding to the display 120 in the actual space, and images to be viewed by each of the eyes are acquired.

<Generating the Virtual Space>

As shown in a lower half of FIG. 21 (i.e., at (b)), a virtual display 130, the virtual left eye 131, the virtual right eye 132, and a virtual HMD display 133 are arranged in the virtual space; and the virtual 3-dimensional object by the 3-dimensional data is arranged inside the virtual display 130 (on the side opposite to the virtual left eye 131). Here, the items describe above correspond to the items arranged in the actual space that is shown in an upper half of FIG. 21 (i.e., at (a)). More specifically, this is carried out as follows. Here, it is assumed that the HMD 110 is worn for the left eye.

Here, a rectangular coordinate system is used as the coordinate system of the actual space, and the upper right corner indicated by "0" at (a) of FIG. 21 is made into the point of origin; and a rectangular coordinate system is used as the coordinate system of the virtual space are made into a rectangular coordinate system, and the upper right corner indicated by "0" at (b) of FIG. 21 is made into the point of origin. Then, an absolute coordinate X1 where the display unit 125 is present in the actual space is computed, and the virtual display 130 is arranged to the absolute coordinate X1 in the virtual space.

Next, an absolute coordinate X2 of the HMD 110 is computed using the relative position acquired by the relative position measuring unit 127. Then, the virtual left eye 131 is arranged to the absolute coordinate X2 in the virtual space. Thus, the absolute coordinate X2 of the HMD 110 in the actual space differs from an absolute coordinate of the left eye. For this reason, if a highly precise arrangement of the virtual left eye is desired, a difference between a coordinate of the left eye and the HMD 110 when wearing the HMD 110 may be beforehand measured, and applied to the absolute coordinate X2; further, a coordinate difference predetermined with reference to a sample person may be used.

Next, an absolute coordinate of the virtual right eye is computed, and the virtual right eye 132 is arranged. The absolute coordinate of the virtual right eye is computed based on the absolute coordinate of the virtual left eye 131, amounts of rotations of the virtual left eye 131 in three directions, namely, pan, tilt, and roll, computed by the relative position measuring unit 127, and a relative vector of the right eye. Here, an initial value of the relative right eye position vector is set at a vector length of 60 mm (the standard length between a person's eyes), and a vector direction being perpendicular to the line of sight, and parallel with a straight line between the ultrasonic loudspeaker 117 and the ultrasonic loudspeaker 118. Further, the vector length and the vector direction of the relative right eye position vector can be adjusted at Step S7-3 where the display position is adjusted.

Then, an absolute coordinate X3 of a position of the virtual image displayed by the display 112 is computed, and a virtual HMD display 133 is arranged at the absolute coordinate X3 of the virtual space.

Arrangement of the 3-dimensional data is performed as follows.

First, a cube is prepared, one side of which cube is equal to a vertical length of the display unit 125. Then, the cube is arranged such that the center of gravity of a virtual 3-dimensional object expressed by the 3-dimensional data may come to the center of the cube. Then, the virtual 3-dimensional object is expanded or reduced such that the virtual 3-dimensional object may be inscribed in the cube, that is, normalized. During this process, the center of gravity of the virtual 3-dimensional object is maintained at the center of the cube. Then, the virtual 3-dimensional object is arranged in the virtual space so that a surface of the cube may be in agreement with the virtual display **130**. Here, it should be noted that the cube is used only for normalizing the virtual 3-dimensional object, and is present in the virtual space.

<Generating the Virtual HMD Image and the Virtual Display Image>

A virtual camera is arranged in the virtual space, and virtually takes an image of the virtual 3-dimensional object expressed by the 3-dimensional data, wherein the virtual HMD display **133** serves as an image-taking plane, and the virtual left eye **131** serves as a focal point. An image photographed with the virtual camera is made into the virtual HMD image.

Similarly, a virtual camera is arranged in the virtual space, and virtually takes an image of the virtual 3-dimensional object expressed by the 3-dimensional data, wherein the virtual display **130** serves as the image-taking plane, and the virtual right eye serves as the focal point. An image photographed with the virtual camera is made into the virtual display image.

The virtual HMD image and the virtual display image are generated as described above.

As required, a display position adjustment may be carried out by the viewing person (Step **S7-3**). More specifically, the viewing person inputs a direction to adjust the position of the image in the display **112** using the input interface **116**. In response to the direction, the virtual right eye position moving unit **113** changes the relative right eye position vector. When a position that provides stereoscopic viewing of the image shown by the display **112** is obtained, the viewing person inputs a direction of completion of the adjustment to the input interface **116** to end the adjustment (Step **S7-4**). The control unit **111** of the HMD **110** provides the relative right eye position vector that has been adjusted to the display **120**, while storing the relative right eye position vector in a storage unit (not illustrated) of the virtual right eye position moving unit **113**. The display **120** stores the relative right eye position vector in a storage unit (not illustrated) of the display image generation unit **128**. Henceforth, the relative right eye position vector is used for calculation of the absolute coordinate of the virtual right eye **132**.

Henceforth, the relative position is consecutively measured; when the relative position is changed, generation and displaying of a display image is automatically repeated; when a rotation direction of a 3-dimensional image is input, according to the rotation direction, the virtual 3-dimensional object is rotated, and generation and displaying of the display image is repeated (Step **S7-5**). More specifically, it is carried out as follows.

The relative position measuring unit **127** of the display **120** continuously measures the relative position between the HMD **110** and the display **120**; whenever there is a change in the relative position, the virtual HMD image and the virtual display image are generated based on the relative position and the relative right eye position vector at the time of the completion of adjustment; and displaying on the display **112** and the display unit **125** is repeated.

Further, the viewing person is able to direct a rotational movement of the virtual 3-dimensional object around the center of gravity using the input interface **116**, when viewing, e.g., the back side of the virtual 3-dimensional object. When the direction is received, the display image generation unit **128** of the display **120** carries out the rotational movement of the virtual 3-dimensional object around the center of gravity of the virtual 3-dimensional object in the virtual space based on the direction of the rotational movement received from the HMD **110**. Then, using the relative right eye position vector at the time of the completion of adjustment and the relative position, the virtual HMD image and the virtual display image are repeatedly generated and displayed on the display **112** and the display unit **125**, respectively, as described above.

Here, the present embodiment is described about the display unit **125** of the display **120** being flat; however, it does not have to be flat. The surface of the display unit may be of, for example, a curved surface such as a spherical surface.

According to an embodiment of the invention, the following effects are obtained in addition to one or more of the effects described above.

(17) The relative position between the HMD **110** and the display **120** is determined by the ultrasonic loudspeakers **117**, and **118**, the ultrasonic microphones **122**, **123**, and **124**, and the relative position measuring unit **127**. The virtual HMD image and the virtual display image are generated based on the relative position. In this way, the virtual HMD image (virtual image) and the virtual display image (real image) are displayed according to the relative position. Accordingly, when the viewing person moves and the relative position between the HMD **110** and the display **120** is gradually changed, stereoscopic viewing is kept available by gradually changing the virtual display image (real image) displayed on the display **120**, and the virtual HMD image (virtual image) displayed on the HMD **110**. For this reason, a more real 3-dimensional image is provided to the viewing person. Further, since the display image generation unit **128** of the display **120** generates the display image (the virtual HMD image, and the virtual display image), the processing load of the HMD **110** is mitigated.

(18) The virtual HMD image and the virtual display image are generated based on the 3-dimensional data. For this reason, the 3-dimensional object expressed by the 3-dimensional data can be viewed from any desired direction, for example, the back side of the object can be viewed by giving the direction to rotationally move the image.

The embodiments described above may be modified in various ways, and examples of modifications are described in the following.

According to the first through the second embodiments, the information is coded into the corresponding 2-dimensional codes **42**, **67**, and **87**. Here, the information includes identification information, difference information, and information about the position of the part that is shown with an elevation using parallax, and is used by the HMD **20** and **50** for acquiring an image to be displayed on the HMD **20** and **50**. It does not have to be the 2-dimensional code, but the identification information may be recorded on RFID, the information on RFID may be read by an RFID reader, and the image to be displayed on the HMD may be acquired based on this information. Further, the difference information and the information about the position may be recorded on RFID, and the information may be used. In this case, a reference item for determining the position of the image on the paper, and for compensating for tilt may be separately prepared, an example of the reference item being a 2-dimensional code including the information about the relative position of the image, and relative size.

According to the first through the third embodiments, the printed matter for stereoscopic viewing carries applicable one of the stereoscopic image **41**, **66**, and the map image **86**, in addition to the corresponding 2-dimensional codes **42**, **67**, and **87**. Nevertheless, the applicable image and 2-dimensional code may be displayed on a display. Further, an image to be shown as a real image and a corresponding 2-dimensional code may be separately presented for stereoscopic viewing, the image and the corresponding 2-dimensional code being simultaneously used.

According to the third embodiment, the printed matter for stereoscopic viewing carries the map image **86** and the 2-dimensional code **87**. Nevertheless, the number of the 2-dimensional codes is not limited to one, but may be two or greater such that 2-dimensional codes containing different elevation data are available for one real image. In this way, the portion to be shown with elevation can be changed.

According to the third embodiment, the display **52** of the HMD **50** shows an image wherein pixel information of an area size 2 is moved to the map image area (8, 1), and pixel information of an area size 2 is moved to (8, 11). Nevertheless, only characters in a specified area can be shown with elevation (3-dimensions). In this case, an image wherein the characters in the specified area ("convenience store" in the case of the example above) are moved to either right or left is displayed on the display **52** of the HMD **50**.

According to the fourth embodiment, stereoscopic viewing is of a moving image, however, the present invention can be realized for stereoscopic viewing of a still image.

Further, the present invention is not limited to these embodiments, but variations and modifications may be made without departing from the scope of the present invention.

The present application is based on Japanese Priority Application No. 2005-240235 filed on Aug. 22, 2005 with the Japanese Patent Office, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. An image display system for stereoscopic viewing a stereoscopic image, comprising:

a real image presentation unit configured to show a first view image of the stereoscopic image as a real image; and

a virtual image presentation unit configured to show a second view image of the stereoscopic image as a virtual image, wherein

the first view image is viewable by one eye of a viewing person, and the second view image is viewable by the other eye of the viewing person, which the first view image and the second view image together form the stereoscopic image,

the virtual image presentation unit includes an image pick-up unit that is configured to take an image of a code image that indicates an address of the second view image, and

the virtual image presentation unit is configured to show the second view image, serving as the virtual image, stored at the address indicated by the code image photographed by the image pick-up unit.

2. The image display system as claimed in claim **1**, wherein the real image presentation unit is a printed matter.

3. The image display system as claimed in claim **1**, wherein the real image presentation unit is a display unit.

4. The image display system as claimed in claim **1**, wherein the virtual image presentation unit is configured to display the second view image, serving as the virtual image, based on an image photographed by the image pick-up unit.

5. An image display system for stereoscopic viewing a stereoscopic image, comprising:

a real image presentation unit configured to show a first view image of the stereoscopic image as a real image; and

a virtual image presentation unit configured to show a second view image of the stereoscopic image as a virtual image, wherein

the first view image is viewable by one eye of a viewing person, and the second view image is viewable by the other eye of the viewing person, which the first view image and the second view image together form the stereoscopic image, and

the virtual image presentation unit includes an image pick-up unit that is configured to take an image of the first view image and a code image, the code image containing data representing differences between the first view image and the second view image, and

the virtual image presentation unit is configured to generate the second view image based on the first view image and the code image that are photographed by the image pick-up unit, and to show the second view image as the virtual image.

6. An image display system for stereoscopic viewing a stereoscopic image, comprising:

a real image presentation unit configured to show a first view image of the stereoscopic image as a real image; and

a virtual image presentation unit configured to show a second view image of the stereoscopic image as a virtual image, wherein

the first view image is viewable by one eye of a viewing person, and the second view image is viewable by the other eye of the viewing person, which the first view image and the second view image together form the stereoscopic image,

the virtual image presentation unit includes an image pick-up unit that is configured to take an image of the first view image and a code image, the code image containing coded data that include coded data of information necessary for forming the second view image based on the first view image, and

the virtual image presentation unit is configured to generate the second view image based on the first view image and the code image that are photographed by the image pick-up unit, and to show the second view image as the virtual image.

7. The image display system as claimed in claim **1**, wherein

the real image presentation unit is configured to present two or more first view images corresponding to different positions as the real image, and

the virtual image presentation unit is configured to present the second view image, serving as the virtual image, corresponding to the first view image shown by the real image presentation unit.

8. The image display system as claimed in claim **1**, wherein

the real image presentation unit is configured to present the first view image as the real image according to a position relation between the virtual image presentation unit and the real image presentation unit, and

the virtual image presentation unit is configured to present the second view image as the virtual image corresponding to the first view image according to the position relation between the virtual image presentation unit and the real image presentation unit.

9. The image display system as claimed in claim **1**, wherein the virtual image presentation unit is a head wearing type single eye display unit.

10. The image display system as claimed in claim **1**, further comprising a relative position determining unit configured to determine a relative position between the virtual image presentation unit and the real image presentation unit.

11. The image display system as claimed in claim **10**, wherein the relative position determining unit includes the image pick-up unit.

12. The image display system as claimed in claim **1**, further comprising a display data transforming unit configured to carry out projective transformation on display data of the second view image shown by the virtual image presentation unit.

13. The image display system as claimed in claim **1**, further comprising a display data status selecting unit configured to carry out projective transformation on display data of the second view image displayed by the virtual image presentation unit according to an operation of the viewing person, and to allow the viewing person to select a state of the display data.

14. The image display system as claimed in claim **13**, further comprising a relative position determining unit configured to determine a relative position between the virtual image presentation unit and the real image presentation unit, and a display data automatic transformation unit configured to automatically carry out the projective transformation on the display data of the second view image shown by the virtual image presentation unit based on information about the selection of the user by the display data status selecting unit and based on the relative position.

15. An image display method for stereoscopic viewing a stereoscopic image, comprising:

showing, by a real image presentation unit, a first view image of the stereoscopic image as a real image,

showing, by a virtual image presentation unit, a second view image of the stereoscopic image as a virtual image, the second view image being based on the first view image; and

generating a code image that contains coded information about a relative position and relative size between the code image and the stereoscopic image, the code image being appended to the stereoscopic image,

wherein the first view image, when viewed by one eye of a viewing person, and the second view image, when viewed by the other eye of the viewing person, together form the stereoscopic image.

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